AG Contract No. KR98 0974TRN
Arizona ECS File: JPA 98-79
Project No. NCHRP Study 9-13
TRACS No.: R0402 07P
Research: Evaluate AASHTO T283
for US-93 Superpave Project

INTERGOVERNMENTAL AGREEMENT
BETWEEN
THE ARIZONA DEPARTMENT OF TRANSPORTATION
AND
THE NEVADA BOARD OF REGENTS
ACTING FOR AND ON BEHALF OF
THE UNIVERSITY OF NEVADA AT RENO

THIS AGREEMENT is entered into 29 July, 1998, pursuant to Arizona Revised Statutes Section 11-952; between the STATE OF ARIZONA, DEPARTMENT OF TRANSPORTATION, acting by and through its RESEARCH DIRECTOR (the "Arizona") and the UNIVERSITY OF NEVADA AT RENO, acting by and through its BOARD OF REGENTS OF THE UNIVERSITY AND COMMUNITY COLLEGE SYSTEM OF NEVADA, ON BEHALF OF THE UNIVERSITY OF NEVADA, RENO (the "UNR").

I. RECITALS

1. Arizona is empowered by Arizona Revised Statutes Section 28-401 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the Arizona.

2. The University is empowered by Nevada Constitution Article 11, Section 4 to enter into this agreement and has authorized the undersigned to execute this agreement on behalf of the UNR.

3. The Arizona and the University desire to conduct research and evaluate the efficacy of the AASHTO T283 test procedure for Superpave mixtures, at an estimated cost of $22,620.00, all at Arizona expense, hereinafter referred to as the Project.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

NO. 22552
Filed with the Secretary of State
Date Filed: 07/29/98
Betsey Bayless
Secretary of State
By Vicky V. Groeneweg

II. SCOPE OF WORK

1. Arizona will:

a. Appoint a Project coordinator within the Arizona's Transportation Research Center to interface with the University relating to the research and development.

b. Provide the University with information and data as may be reasonably available to assist in the Project research and development.

c. Reimburse the University within forty-five (45) days after receipt and approval of monthly invoices, in a total amount not to exceed $22,620.00.

2. The University will:

a. Appoint a Project coordinator at the University (UNR) to interface with the Arizona relating to the research and development.

b. Accomplish the research and development generally in accordance with Exhibit A, which is attached hereto and made a part hereof, including the evaluation of the efficacy of the AASHTO T283 test procedure for Superpave mixtures, by documenting the program, data derived, and the final results. Such reports will be in a format compliant with the Arizona's "Guidelines for Preparing Research Reports."

c. No more often than monthly, invoice the Arizona in the form of Exhibit B attached hereto, supported by narrative reports and an accounting of monthly costs and expenditures on the Project. Upon completion of the Project, provide the Arizona with a detailed final report.

III. MISCELLANEOUS PROVISIONS

1. This agreement shall become effective upon filing with the Arizona Secretary of State, and shall remain in force and effect until completion of said Project and reimbursements; provided, however, that this agreement, may be cancelled at any time prior to the commencement of performance under this agreement, upon thirty (30) days written notice to the other party.

2. The parties agree to comply with all respective applicable state and federal laws, rules, regulations and executive orders governing equal employment opportunity, immigration, nondiscrimination and affirmative action.

3. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511 pertaining to conflicts of interest on behalf of Arizona state employees..

4. The provisions of Arizona Revised Statutes Section 35-214 pertaining to audit are applicable to this contract.

5. In the event of any controversy which may arise out of this agreement, the parties hereto agree to abide by required arbitration as is set forth for public works contracts in Arizona Revised Statutes Section 12-1518.

6. All notices or demands upon any party to this agreement relating to the agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Department of Transportation
Joint Project Administration
205 S. 17th Avenue - 616E
Phoenix, AZ 85007

University of Nevada - Reno
C.E. Department
Reno, NV 89557

7. Attached hereto and incorporated herein is the written determination of legal counsel that the parties are authorized under the laws of their respective States to enter into this agreement and that the agreement is in proper form.

IN WITNESS WHEREOF, the parties have executed this agreement the day and year first above written.

NEVADA BOARD OF REGENTS
The University of Nevada
At Reno

By Mary B. Husemoller 7/2/98
MARY B. HUSEMOLLER, Director
Sponsored Projects
Administration

STATE OF ARIZONA
Department of Transportation

By [signature]

Dick Wright
Deputy Director
ADOT

98-79
21may

JPA 98-79

RESOLUTION

BE IT RESOLVED on this 20th day of May 1998, that I, the undersigned MARY E. PETERS, as Director of the Arizona Department of Transportation, have determined that it is in the best interests of the State of Arizona that the Department of Transportation, acting by and through the Intermodal Transportation Division, to enter into an agreement with the University of Nevada for the purpose of defining responsibilities for conducting research to evaluate AASHTO T283 for the US-93 Superpave project.

Therefore, authorization is hereby granted to draft said agreement which, upon completion, shall be submitted to the Ass't State Engineer for approval and execution.

DAVID ALLOCCO, Manager
Engineering Technical Group
for Mary E. Peters, Director

Joseph N. Crowley
President

UNIVERSITY OF NEVADA RENO

President's Office/001
Reno, Nevada 89557-0001
(702) 784-1805

RECEIVED

JAN 25 1996

GRADUATE SCHOOL
RESEARCH OFFICE

January 23, 1996

To: Richard Jarvis, Chancellor

From: Joe Crowley Joe Crowley

Subject: Signature Authority on Sponsored Projects

We have recently completed an internal review of policies and procedures related to the administration of sponsored projects. In order to streamline the process, it was recommended that I delegate all signature authority to our Vice President for Research. I concur with that recommendation.

Dr. Hunter's Office of Sponsored Projects Administration (OSPA) will assume responsibility for review and approval of all sponsored projects that do not require your signature or approval by the Regents. In the case of those sponsored projects that cannot be signed locally, they will be forwarded directly from the OSPA to your office.

I am quite confident that the professional sponsored project administrators in Dr. Hunter's office will do an excellent job.

cc: Ken Hunter
Ashok Dhingra

STATE OF ARIZONA

OFFICE OF THE ATTORNEY GENERAL

1275 WEST WASHINGTON, PHOENIX 85007-2926

GRANT WOODS
ATTORNEY GENERAL

TRN Main: (602) 542-1680
Direct: (602) 542-8837
Fax: (602) 542-3646
MAIN PHONE : 542-5025
TELECOPIER : 542-4085

INTERGOVERNMENTAL AGREEMENT DETERMINATION

A.G. Contract No. KR98-0974TRN, an agreement between public agencies, has been reviewed pursuant to A.R.S. § 11-952, as amended, by the undersigned Assistant Attorney General who has determined that it is in the proper form and is within the powers and authority granted to the State of Arizona.

No opinion is expressed as to the authority of the remaining parties, other than the State or its agencies, to enter into said agreement.

DATE July 23, 1998.

GRANT WOODS
Attorney General

JAMES R. REDPATH
Assistant Attorney General
Transportation Section

JRR:et/13935

Enc.

PRELIMINARY TEST PLAN

FOR

MOISTURE SENSITIVITY TESTING

OF

ADOT US 93 TEST SECTIONS

prepared by

University of Nevada

30 April 1998

INTRODUCTION

The US 93 experimental pavement test section in Arizona has experienced premature fatigue cracking in the Superpave coarse graded test sections. ADOT typical mixtures have not experienced the same degree of fatigue cracking at this site. A preliminary field investigation conducted by ADOT with FHWA representatives indicates that moisture sensitivity may be the primary cause of premature fatigue cracking in the Superpave designed mixtures.

The Superpave volumetric mixture design method was used to design the Superpave mixtures (19 and 12.5 mm nominal maximum size mixtures) and the Marshall mixture design method was used to design the ADOT specified mixtures. The Superpave mixture design method, which utilized AASHTO T 283 as the water sensitivity test, did not indicate the need for the use of an antistrip agent (tests were performed on 150 mm diameter gyratory compacted samples by the Asphalt Institute). ADOT uses a revised unconfined compression test to determine water sensitivity. Based on ADOT test results an antistrip agent (portland cement) was utilized in all ADOT mixtures.

Conformation of the mixture design water sensitivity testing and water sensitivity testing on core samples is needed to determine if laboratory test methods adequately predict the field performance of mixtures subjected to moisture. A laboratory testing program is describe below which proposes the testing of laboratory mixed-laboratory compacted samples and field mixed-field compacted (core) samples.

The proposed test program will be performed with testing associated with NCHRP Project 9-13 "Evaluation of Moisture Sensitivity Tests" now being performed at the University of Nevada. A copy of the NCHRP work plan is attached.

OBJECTIVES

The objectives of the project are given below:

1. determine the water sensitivity of selected paving mixtures used on the US 93 experimental pavement project in Arizona
2. compare the water sensitivity (as determined by AASHTO T 283) of 150 and 100 mm diameter samples prepared by Gyratory compaction and Marshall compaction
3. compare the water sensitivity (as determined by AASHTO T 283) of 150 and 100 mm diameter core samples
4. determine the effectiveness of portland cement as an antistrip agent for the mixtures used on the US 93 project

TEST PROGRAM

A five task research program will be required to meet the objectives. The test program is described below.

Task 1.0-Obtain and Prepare Materials
The aggregates and asphalt binders used on the experimental project are located in the FHWA Materials Reference Library (MRL) located in Reno, Nevada. These materials will be located in the MRL and transported to the University of Nevada pavements and materials laboratory. The aggregates will be dried and sized. The asphalt binder will be heated and transferred to suitable containers for mixing.

Task 2.0-Core Samples
Core samples will be obtained by ADOT from the experimental test sections and shipped to the University of Nevada. Both 150 mm and 100 mm core samples will be obtained.

Task 3.0-Laboratory Mixed-Laboratory Compacted Test Program
Table 1 describes this test program. A total of 132 samples will be prepared and tested. Samples will be prepared by both Gyratory and Marshall compaction methods. The Gyratory compactor will be used to prepare both 150 and 100 mm samples. Resilient modulus and tensile strength will be obtained as described on Figures 1 and 2.

Task 4.0-Core Test Program
Table 2 describes this test program. A total of 72 cores of 150 and 100 mm will be obtained and tested. The test sequence shown on Figure 1 will be used to determine the water sensitivity of the core samples.

Task 5.0-Reports
The data will be analyzed and a final report will be prepared.

SCHEDULE

The project can be initiated after the May 15, 1998 and will be completed by August 15, 1998.

ESTIMATED BUDGET

The estimated budget for this project is shown below.

prepare and test samples for Task 2.0	
132 samples x $125 per sample=	$16,500
prepare and test samples for Task 3.0	
72 samples x $85 per sample=	6,120
Total	$22,620

TABLE. 1: LABORATORY MIXED - LABORATORY COMPACTED SAMPLES

MIX DESIGNATION	AMOUNT OF P.C, %	FREEZE THAW CYCLE	TYPE OF COMPACTION: GYRATORY (150X95 mm)	GYRATORY (100X62 mm)	MARSHALL (100X62 mm)	HVEEM (100X62 mm)		
SUPERPAVE A 19 mm	0	N						
		Y	Y	Y	Y			
	1.0	N						
		Y	Y	Y	Y			
SUPERPAVE B 12.5 mm	0	N						
		Y	X		X			
	1.0	N						
		Y						
ADOT A	0	N						
		Y	Y	Y	Y			
	1.0	N						
		Y	Y	Y	Y			
ADOT B	0	N						
		Y	X		X			
	1.0	N						
		Y						

6-8% - AIR VOIDS
75% - SATURATION
4 hr - LOOSE mix AGING (135 C)
96 hr - COMPACTED mix AGING (ROOM TEMP)
X - 6 sample test program $\boxed{4X6 = 24 \text{ SAMPLES}}$
Y - 9 sample test program (WITH & WITHOUT FREEZE-THAW CYCLE) $\boxed{12X9 = 108 \text{ SAMPLES}}$
132 TOTAL SAMPLES

TABLE 2: FIELD MIXED - FIELD COMPACTED (CORE) SAMPLES

MIX DESIGNATION	AMOUNT OF P.C., %	FREEZE THAW CYCLE	SIZE OF CORE	
			150 mm DIAMETER	100 mm DIAMETER
SUPERPAVE A 19 mm	0	N		
		Y	Y	Y
	1.0	N		
		Y		
SUPERPAVE B 25.5 mm ~~12.5~~ mm	0	N		
		Y	Y	Y
	1.0	N		
		Y		
ADOT A	0	N		
		Y		
	1.0	N		
		Y	Y	Y
ADOT B	0	N		
		Y		
	1.0	N		
		Y	Y	Y

~~6-8% = AIR VOIDS~~

~~7.5% SATURATION~~

~~4 hr — LOOSE MIX AGING~~ (135 C)

~~96 hr = COMPACTED MIX AGING (ROOM TEMP)~~

Y - 9 SAMPLE TEST PROGRAM (WITH & WITHOUT FREEZE-THAW CYCLE)

4 X 9 = 36 150 mm CORES

4 X 9 = 36 100 mm CORES

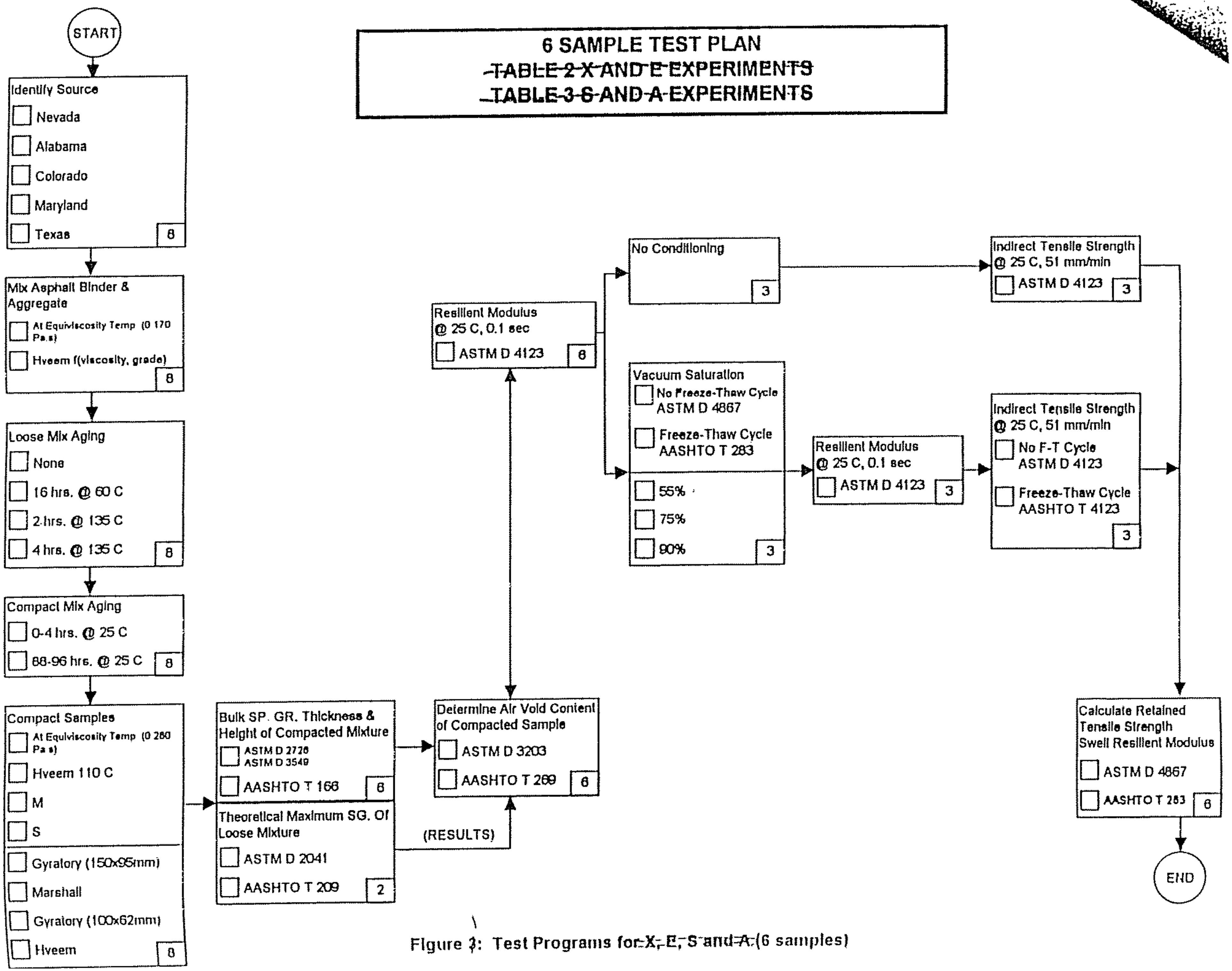


Figure 3: Test Programs for ~~X, E, S and A~~ (6 samples)

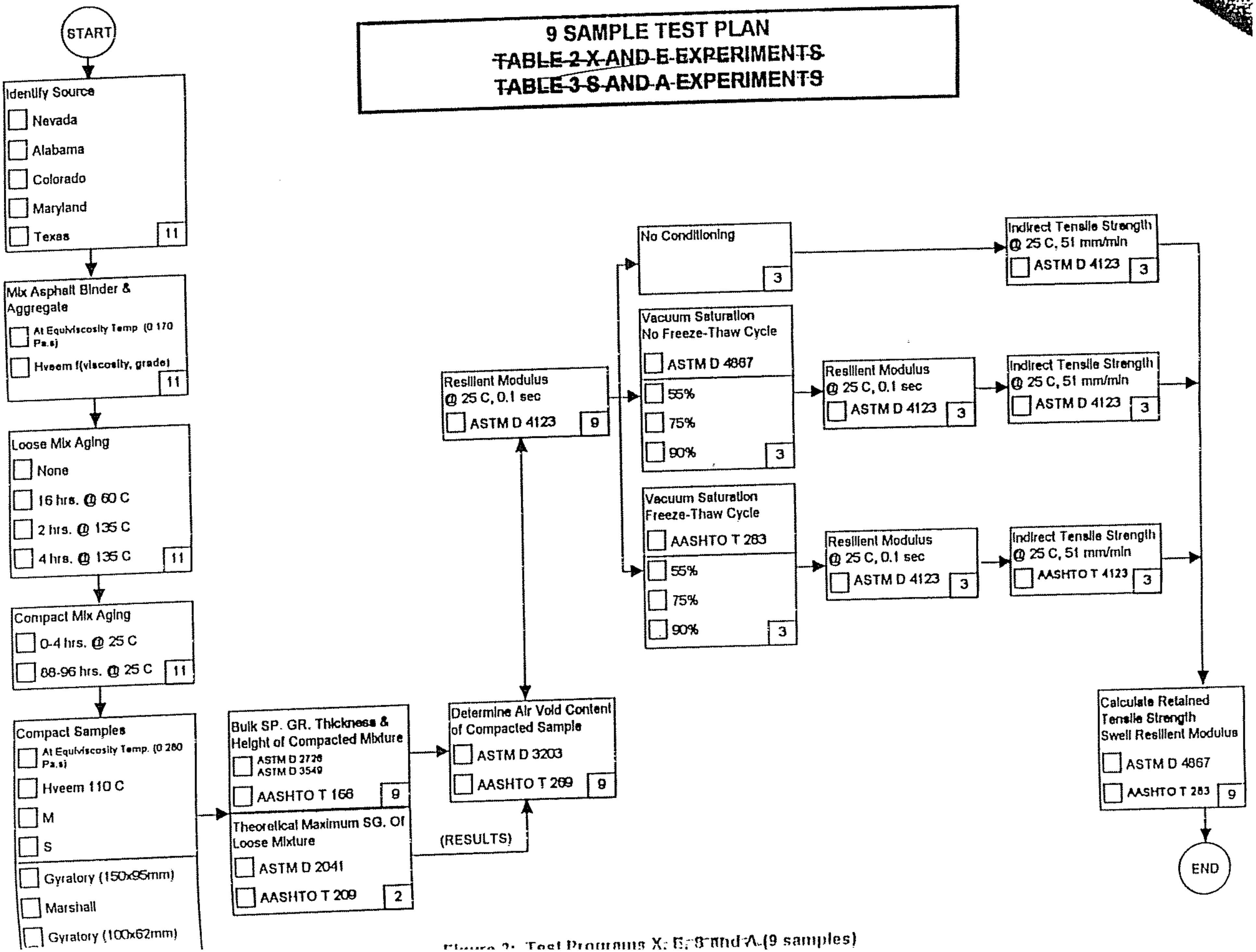


Figure 2: Test Programs X, E, S and A (9 samples)

NCHRP

Project Number

9-13
Evaluation of Moisture Sensitivity Tests

WORK PLAN

TRANSPORTATION RESEARCH BOARD
NAS-NRC

<u>LIMITED USE DOCUMENT</u>

Civil Engineering Department
University of Nevada, Reno
Reno, Nevada 89557

December 29. 1997

Table 1. Water Sensitivity Tests Comparison

Test Parameter	ASTM D4867	AASHTO T283	Superpave
Specimen Size	62 mm x 100 mm	62 mm x 100 mm	95 mm x 150 mm
Mixing Temperature	Depends on Compaction Method (1)	Depends on Compaction Method	Equiviscous (0.170 Pa•s)
Loose Mix Curing	None	Cool at Room Temp. 2 hrs. Cure at 60°C - 16 hrs.	135 C - 4 hrs.
Compaction Temperature	Depends on Compaction Method (1) (1-2 hrs. in oven)	135 C (2 hrs. in oven)	Equiviscous (0.280 Pa•s)
Compacted Mixture Curing	0-24 hrs. @ Room Temp. Before Start of Testing	72 to 96 hrs. @ Room Temp. Before Start of Testing	Same as AASHTO T283
Air Void Content of Compacted Specimen, %	6-8	6-8	Same as AASHTO T283
Sample Grouping	Average Air Voids of Two sets of Samples About Same	Average Air voids of Two Sets of Samples About Same	Same as AASHTO T283
Saturation	•55 - 80% •About 20 in. Hg for 5 min. •Calculations Different than AASHTO T283	•55-80% •10-26 in. Hg for 5-10 min. •Calculation Different than ASTM D4867	Same as AASHTO T283
Swell Determination	yes	no	Same as AASHTO T283
Freeze	-18 $\pm$ 2 C for min. 15 hrs. (Optional by Note)	-18 $\pm$ 3 C for min. 16 hrs. Remove by Note	Same As AASHTO T283
Water Soak	60 $\pm$ 1.0 C for 24 hrs.	60 $\pm$ 0.1 C for 24 $\pm$ 1 hr.	Same As AASHTO T283
Strength Property	Indirect Tensile at 25 $\pm$ 1 C with Loading Rate of 51 mm per min.	Indirect Tensile at 25 $\pm$ 1 C	Same As AASHTO T283
Precision and Bias	yes	no	no

(1) - Use mixing temperature as specified by:
Marshall Compaction (ASTM D1559, AASHTO T245)
Kneading Compaction (ASTM D1561, AASHTO T247)
Corps of Engineers Gyratory (ASTM D3387)
Compression (ASTM D1074)

Table 3: Engineering Based Special Studies - Task 2

Compaction		Gyratory (150 x 95 mm)				Gyratory (100 x 62 mm)				Marshall (100 x 62 mm)				Hveem (100 x 62 mm)			
% Saturation		75				75				75				75			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																
Source 1 Nevada (N)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	E,M		X,M		S		S		E,M		X,M		A		A	
Source 2 Alabama (A)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S,M		X,M		S		S		S,M		S,M		A		A	
Source 3 Colorado ©	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S,M		X,M		S		S		S,M		S,M		A		A	

Table 3: Engineering Based Special Studies - Continued

Compaction		Gyratory (150 x 95 mm)				Gyratory (100 x 62 mm)				Marshall (100 x 62 mm)				Hveem (100 x 62 mm)			
% Saturation		75				75				75				75			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																
Source 4 Maryland (M)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	X		S		S		S		X		S		A		A	
Source 5 Texas (T)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S		S		S		S		S		S		A		A	

Notes

X - Statistical Based Experiment (from Table 2)
E - Additional Testing for Engineering Based Experiment (from Table 2)
S - Speciality Study as part of NCHRP 9-13 (100 mm Gyratory sample)
M - Speciality Study as part of NCHRP 9-13 (influence of resilient modules on tensile strength)

- Samples for X and E Test Sequences shown on Table 2
- Samples for Test Sequence S
  9 sets x 9 samples = 81
  4 sets x 3 samples = 12
  Total 93
- Samples for Test Sequence M
  6 sets x 15 samples = 90
- Samples for Test Sequence A
  5 sets x 9 samples = 45

Table 2: Statistical and Engineering Based Experimental Plan - Task 2

Compaction		Gyratory (150 x 95 mm)*												Marshall (100 x 62 mm)**											
% Saturation		55				75				90				55				75				90			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																								
Source 1 Nevada (N)	None	E	X	X	E	X	X	X	X	X	E	E	X	E	E	E	E	E	E	E	E	E	E	E	X
	16 h/60° C	E	X	X	E	X	X	E	X	X	E	X	X	E	E	E	E	E	X	E	E	E	E	E	E
	2 h/135° C	X	X	X	X	X	E	E	X	E	X	X	E	E	E	X	E	X	E	E	E	E	E	E	E
	4 h/135° C	X	E	E	X	E	X	X	E	X	X	X	X	E	E	X	E	E	E	E	E	E	X	E	E
Source 2 Alabama (A)	None	X	X		X	X		X	X		X	X		X							X				
	16 h/60° C	X		X	X		X	X		X	X		X				X								
	2 h/135° C		X	X		X	X	X	X	X			X								X				
	4 h/135° C		X	X		X			X	X	X	X	X									X			
Source 3 Colorado (C)	None	X			X		X	X		X	X	X	X							X					
	16 h/60° C	X	X		X	X		X	X		X	X		X											
	2 h/135° C	X		X	X	X	X		X		X	X											X		
	4 h/135° C		X	X		X	X	X	X	X			X				X								

Table 2: Statistical and Engineering Based Experimental Plan - Continued

Compaction		Gyratory (150 x 95 mm)*												Marshall (100 x 62 mm)**											
% Saturation		55				75				90				55				75				90			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																								
Source 4 Maryland (M)	None	X	X	X		X			X		X	X			X										
	16 h/60° C		X	X	X	X	X	X		X		X												X	
	2 h/135° C	X			X		X	X		X	X	X	X		X									X	
	4 h/135° C	X	X		X	X		X	X		X	X						X			X				
Source 5 Texas (T)	None	X			X	X	X		X	X		X						X							
	16 h/60° C	X	X	X		X		X		X	X	X	X			X						X			
	2 h/135° C		X	X	X	X	X	X		X	X		X	X						X					
	4 h/135° C	X		X	X		X		X		X	X													X

NOTES

X - Statistical Based Experiment

E - Additional Testing for Engineering Based Experimental

- Gyratory Samples

  58 sets x 9 samples = 522

  57 sets x 6 samples = 342

  Total 864

- Marshall Samples

  24 sets x 9 samples = 216

  21 sets x 6 samples = 126

  Total 342

Table 4: Ruggedness Test Program*

Saturation, Percent	Low								High							
Freeze/Thaw	1 cycle				None				1 cycle				None			
Compacted Mix Aging	0-4**		88-96**		0-4		88-96		0-4		88-96		88-96		88-96	
Loose Mix Aging Aggregate Source	*** Y	*** N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Source 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Source 2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Source 3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x - replicate samples for complete factorial incomplete, factorial (Latin Square or a Youden Square will be used to select final experiment. (approximately 80 to 100 samples per laboratory three laboratories Auburn University, University of Texas, and University of Nevada)

* To be conducted at University of Nevada, University of Texas an Auburn University Superpave Regional Centers

** Hours

*** Y - 4 hours @ 135 C
N - No Aging

NCHRP

Project Number

9-13
Evaluation of Moisture Sensitivity Tests

WORK PLAN

TRANSPORTATION RESEARCH BOARD
NAS-NRC

<u>LIMITED USE DOCUMENT</u>

Civil Engineering Department
University of Nevada, Reno
Reno, Nevada 89557

December 29. 1997

NCHRP Project:	9-13 "Evaluation of Moisture Sensitivity Test
Proposing Agency:	Civil Engineering Department/257 University of Nevada, Reno Reno, Nevada 89557 702-784-6873
Person Submitting Proposal:	Jon A. Epps Peter Sebaaly
Proposal Written By:	Jon A. Epps and Peter Sebaaly in response to evaluations of "Statements of Qualifications and Availability due June 28, 1996
Principal Investigators:	Jon A. Epps, Professor Telephone: 702-784-6873 FAX: 702-784-1429 e-mail: epps@unr.edu Peter Sebaaly, Associate Professor Telephone: 702-784-6565 FAX: 702-784-1429 e-mail: sebaaly@scs.unr.edu
Administrative Officer:	Ken Hunter, V.P. for Research 702-784-6869
Proposed Contract Period:	12 Months
Total Contract Amount:	$150,000
Fixed-Fee Portion:	100%

Table of Contents

EVALUATION OF MOISTURE SENSITIVITY TEST

WORK PLAN

1.0 Introduction

1.1 General Observations

In the late 1970s and early 1980s a significant number of pavements in the United States began to experience distress associated with moisture sensitivity of hot mix asphalt materials. Premature rutting, raveling and wear of pavements were observed on many pavements. The causes of this sudden increase in pavement distress due to water sensitivity has not been conclusively identified. Practitioners and researchers suggest that changes in asphalt binders, decreases in asphalt binder content to satisfy rutting associated with increases in traffic (traffic volume, traffic weight and tire pressure), changes in aggregate quality, more widespread use of selected design features (open graded friction courses, chip seals and fabric interlayers) and poor quality control were primarily responsible for increased water sensitivity problems.

Regardless of the cause of this moisture related premature distress, methods are needed to identify hot mix asphalt behavior in the presence of moisture. Test methods and pavement performance prediction tools need to be developed that couple the effects of moisture on the properties of hot mix asphalt mixtures with performance prediction to estimate the behavior of the paving mixture to resist rutting, fatigue and thermal cracking when subjected to moisture under different traffic levels in various climates.

1.2 Current State of the Practice

Methods are presently not available to couple the effects of moisture on material properties with pavement performance prediction. Most public agencies use tests on loose or compacted hot mix asphalt to determine water sensitivity of the paving material. These tests results can not be used directly to rationally predict performance. Only limited correlations have been established between test results and observed performance of pavements which contain the tested hot mix asphalt.

The test methods listed below are national standard and are used by public agencies:

AASHTO T 283 "Resistance of Compacted Bituminous Mixture to Moisture Induced Damage"

ASTM	D 4867	"Effect of Moisture on Asphalt Concrete Paving Mixtures"
AASHTO T 165 ASTM D 1075		"Effect of Water on Compressive Strength of Compacted Bituminous Mixtures"
ASTM	D 3625	"Effect of Water on Bituminous-Coated Aggregate Using Boiling Water

Other laboratory test methods are used by public agencies but are not national standards. These test methods include Marshall samples subjected to immersion, Hveem samples subjected to moisture vapor and a pedestal freeze-thaw test. The SHRP research program developed a test method that is presently an AASHTO Provisional Standard (TP 34) "Moisture Sensitivity Characteristics of Compacted Bituminous Mixtures Subjected to Hot and Cold Climate Conditions."

The present Superpave methodology does not couple the water sensitivity of the hot mix asphalt paving mixture with climate and traffic to allow for pavement performance prediction for a particular paving project. The present Superpave methodology uses AASHTO T 283 to evaluate the susceptibility of hot mix asphalt to moisture. The moisture sensitivity test is performed on a laboratory mixed, gyratory compacted sample as part of the mixture design process. The sample is prepared at the design asphalt content and at the design gradation as defined by the job mix formula (JMF) for the project.

1.3 AASHTO T 283 and Superpave

AASHTO T 283 is based on research performed by Lottman and subsequent research performed by Root and Tunnicliff. The AASHTO method indicates that it is suitable for testing samples prepared as part of the mixture design process (laboratory mixed-laboratory compacted), as part of the plant control process (field mixed-laboratory compacted and cores taken from the roadway (field mixed-field compacted). Laboratory compacted samples can be prepared by the Marshall, Hveem or Corps of Engineers Gyratory method.

The AASHTO procedure ages the mixed and loose, hot mix asphalt for 16 hours at 60 C. After compaction to an air void content of 7 plus or minus 1 percent, the samples are extruded from the compaction mold and allowed to cure from 72 to 96 hours (3 to 4 days) at room temperature. The samples are then placed under water and a vacuum is used to saturate the samples to a level between 55 and 80 percent. A freeze cycle (16 hours at -18 C) and a thaw/soak cycle (24 hours at 60 C) are used to condition the sample prior to indirect tension testing.

The Superpave volumetric mixture design method uses the SHRP gyratory compactor to prepare 150 mm diameter by about 115 mm samples (according to the Superpave procedures samples are to be compacted to 95 mm in height at seven percent plus or minus one percent air voids for AASHTO T 283 testing). The Superpave sample preparation method conditions the mixed and loose, hot mix asphalt sample for 4 hour at 135 C (the 4 hour time may be reduced to 2 hours for testing volumetric, gyratory compaction properties only). Thus, the differences between the AASHTO T 283 sample preparation method and the Superpave gyratory sample preparation method include the time and temperature of aging and the size of the sample (diameter and height).

SHRP recommended the use of AASHTO T 283 to evaluate the water sensitivity of hot mix asphalt within the Superpave volumetric mixture design system. This recommendation was made by the SHRP asphalt research team with little testing to establish retained tensile strength ratio correlations among sample preparation methods (sample conditioning, method of compaction and size of samples). This deficiency in the research was recognized by the SHRP asphalt research team, a NCHRP research project to define needed Superpave related research and the FHWA Asphalt Mixture Technical Working Group. Research project, NCHRP Project 9-13 " Evaluation of Moisture Sensitivity Tests" was developed to address some of the identified research needs relative to the use of AASHTO T 283 with the Superpave volumetric design method.

1.4 Project Objectives

The objective of this research project is to "evaluate AASHTO T 283 and to recommend changes to make it compatible with the Superpave system."

The NCHRP panel responsible for the development of this project recognized that research is also needed to determine correlations between moisture damage tests and field performance. This second objective will not be addressed in the research effort described below.

2.0 Research Approach

2.1 General Considerations

The response variables of indirect tensile strength at 25° C, resilient modulus at 25° C and percent swell can be measured before and after conditioning of the hot mix asphalt samples. The independent variables of importance and that could be included in the study are given below. This listing is largely based on the summary of AASHTO T283, ASTM D4867 and the Superpave test methods summarized in Table 1.

1. compaction method
    a. Superpave gyratory compactor
    b. Marshall impact compactor
    c. Hveem kneading compactor

2. sample diameter and height
    a. gyratory compactor-100 mm diameter by 62 mm
    b. gyratory compactor-150 mm diameter by 95 mm
    c. Marshall compactor-100 mm diameter by 62 mm
    d. Hveem compactor -100 mm diameter by 62 mm

3. aging/curing method on loose hot mix asphalt
    a. AASHTO T 283-16 hours at 60 C
    b. Superpave - 2 hours at 135 C
    c. Superpave - 4 hours at 135 C
    d. - no curing

4. aging/curing method on compacted hot mix asphalt
    a. ASTM D4867 - 0 to 24 hours at room temperature
    b. AASHTO T283 - 72 to 96 hours at room temperature

5. degree of saturation
    a. 55 percent
    b. 75 percent
    c. 90 percent

6. type of aggregate
    a. Alabama/Georgia granite of moderate to low water sensitivity
    b. Colorado of high water sensitivity
    c. Texas of high water sensitivity
    d. Nevada of moderate or high water sensitivity
    e. Maryland of moderate water sensitivity

7. freeze-thaw cycles
    a. none
    b. one

8. type of antistrip additive
    a. none
    b. liquid antistrip
    c. dry hydrated lime on wet aggregate

9. hot mix asphalt mixing
    a. laboratory
    b. field (plant)

Partial factorial experimental designs (as defined below) will be used to determine the affect of many of these independent variables on indirect tensile strength, resilient modulus and percent swell. Resilient modulus will be used in the special and auxiliary studies initially. Depending on the results of this portion of the research, resilient modulus will be continued or discontinued.

Compaction Method and Sample Size

The Superpave gyratory and Marshall compaction methods were selected for study as they are currently in widespread use or will be in widespread use in the future. Sample diameter and heights are those currently used by most public agencies that use the Superpave Gyratory and Marshall compactors. The gyratory sample size of 150 mm diameter by 95 mm is required in the Superpave volumetric design procedure. Superpave gyratory compaction equipment has the capability of compacting 100 mm diameter samples. The Hveem method was not included in the study at the request of the panel. A small graduate study project will include a limited number of Hveem compacted samples to be evaluated. The Corps of Engineers Gyratory compactor is not widely used.

Aging/Curing on Loose Hot Mix Asphalt

The aging/curing methods selected for loose, hot mix asphalt are those used by AASHTO T 283 and Superpave (4 hours). Research has indicated that the 4 hour Superpave aging can be reduced to 2 hours and not influence the results of the volumetric design procedure. If aging is not required for sample preparation, the time required to perform the water sensitivity test can be reduced.

AASHTO T283 requires a compacted mixture aging/curing period of from 72 to 96 hours (3 to 4 days). ASTM D4867 indicates that the aging/curing period of from 0 to 24 hours is appropriate prior to the start of the test. Compacted sample aging/cure periods of from 0 to 4 hours and from 88 to 96 hours at room temperature will be included in the test program.

Saturation

The degree of saturation influences the water sensitivity test results. AASHTO T283 and ASTM D4867 indicate that the degree of saturation should be between 55 and 80 percent. Some states and the original Lottman procedure used higher saturation percentages.

Aggregate Type

Five aggregates will be selected to span a range in observed field water sensitivity. Aggregates from the states of Alabama, Colorado, Maryland, Nevada, and Texas will be selected. The Superpave Regional Centers in Alabama and Texas will assist in identifying and obtaining the aggregates. The aggregates from Colorado, Nevada, and Texas will be highly water sensitive. The aggregates from Alabama and Maryland will have low to moderate water sensitivity.

The aggregates will be selected from on going projects that are Superpave volumetric mixture design projects. Asphalt binders from these projects will also be sampled and used. The mix designs used for these field projects will be used with limited verification on this research project. (3 asphalt binder contents at JMF or field constructed gradation).

Freeze-Thaw Cycles

Some public agencies use the one freeze-thaw cycle (AASHTO T 283 and others do not use a freeze cycle (ASTM D 4867). A significance difference in test results occur due to the inclusion or absence of a freeze-thaw cycle.

Antistrip Agent

A wide variety of antistrip agents are evaluated by AASHTO T283 and ASTM D4867. At the request of the panel, an antistrip research task will not be included in the study.

Mixing

The AASHTO T283 test is intended for use as a mixture design test (laboratory mixed- laboratory compacted), and as a field control test (field mixed-laboratory compacted or field mixed-field compacted or core). At the request of the panel only laboratory mixed-laboratory compacted samples will be evaluated in this study.

2.2 Research Plan

A four task research plan is proposed for the study. The study tasks are defined below.

<u>Task 1</u>. <u>Identify Material Sources and Projects, and Perform Sampling</u>

Five projects will be identified and samples of the asphalt binder and aggregates will be obtained. Samples of the aggregates and the asphalt binder will be obtained during construction if possible.

The criteria for project selection will include:

1. degree of cooperation obtained from the state highway administration

2. availability of mixture design information

3. project should be constructed in the early or mid summer of 1997 and

4. aggregate and asphalt combination used on the project have known water sensitivity (low, moderate, high).

Since some testing in the project will be performed by Auburn University (Superpave Regional Center), Colorado Department of Transportation, University of Nevada (Superpave Regional Center and University of Texas (Superpave Regional Center), it is desirable to have samples from Alabama, Colorado, Nevada and Texas. It is anticipated that field sampling and sample splitting can be performed by these four organizations and Maryland.

Task 2. Correlations Among AASHTO T283, ASTM D4867 and Superpave

The test plan (Tables 1 and 2) for this task has been developed to evaluate the influence of compaction method, sample size, aging/curing of loose hot mix asphalt, aging/curing of compacted hot mix asphalt, degree of water saturation and number of freeze-thaw cycles on the water sensitivity of hot mix asphalt prepared in the laboratory. The partial factorial experimental design shown in Table 2 is proposed for use. The factorial design was developed by the project statician to evaluate the multiple interactions. Additional tests were added to this statistical factorial design for engineering purposes.

Specific testing programs were added for engineering purposes to provide for a complete factorial for a single aggregate as shown in Table 2 with the designation "E". Table 3 defines the additional testing that has been added to evaluate 100 mm by 62 mm Superpave gyratory compacted samples (specialty study "S"), to evaluate the influence of performing resilient modulus testing prior to indirect tensile testing (specialty study "M") and to evaluate Hveem kneading compaction (auxiliary study "A"). The auxiliary study will be performed as part of a graduate student project without funding from this project. A total of 1389 samples will be prepared and tested in this task.

The resilient modulus testing will be performed on the specialty studies ("S" and "M") and its use will be continued or discontinued based on the test results. The resilient modulus is sensitive to asphalt binder properties and is an indication of load carrying ability of a hot mix asphalt paving material. The resilient modulus test has value; however, at present few laboratories are equipped to perform the test.

The majority of the testing will be performed on the Nevada aggregate and asphalt as it will be less costly to obtain. Aggregates and asphalts from Alabama, Colorado, Maryland, and Texas are included in the study to determine the influence of different aggregates and asphalts on the test results.

Current test methods use the different aging methods shown in Table 1. Different degrees of saturation are included as saturation is known to influence test results. Some mixtures will be subjected to vacuum saturation without a freeze-thaw cycle while other samples from the same mixture will be subjected to a freeze-thaw cycle after saturation. Resilient modulus, indirect tensile strength and percent swell will be determined (as appropriate) for each of the sample preparation and testing variations.

The testing described on Tables 2 and 3 will be accomplished in the sequence provided below and associated with 5 experimental programs.

Subtask 2.1 Resilient Modulus and Indirect Tensile Testing (Test Program "M")

Special study "M" will be performed initially to evaluate the influence of performing resilient modulus testing prior to indirect tensile testing. Table 3 and Figure 1 describe this test program which will require the fabrication and testing of 90 samples.

Subtask 2.2 Superpave 100 mm Diameter Samples (Test Program "S")

Specialty study "S" will be performed to evaluate 100 mm by 62 mm Superpave gyratory compacted samples relative to the more conventional 150 mm by 95 mm Superpave gyratory compacted samples. Table 3 and Figure 2 describe this test program which will require the fabrication and testing of 93 samples.

Subtask 2.3 Kneading Compacted Samples (Test Program "A")

Auxiliary study "A" will be performed to evaluate the effect of Hveem kneading compacted samples as compared to Marshall and gyratory compaction. Table 3 and Figure 2 describe this test program which will require the fabrication and testing of 45 samples. Test Program "A" will be performed at no cost to the project.

Subtask 2.4 Main Test Program (Test Program "X" and "E")

This is the main test program. The portion of these test programs that allow for a direct comparison with Test Programs "M", "S" and "A" will be scheduled first (Subtask 2.4.1). The remainder of the test program for this subtask will then be competed (Subtask 2.4.2). Table 2 and Figures 2 and 3 describe these test programs. A total of 1206 samples will require fabrication and testing.

<u>Task 3.</u> <u>Ruggedness Study</u>

The test plan for this task has been prepared to develop a preliminary ruggedness experiment for AASHTO T 283 as revised by this study. The proposed test plan is shown in Table 4. This test plan will likely change based on the results from Task 2. A test method will be prepared prior to the initiation of the ruggedness testing. The factors with the largest effect on test results are likely to be, saturation level, freeze-thaw cycles and loose mix and compacted mix aging. Each factor will be tested at two levels by three laboratories on three aggregates. A Latin Square or Youden Square incomplete factorial will be used. Each lab will test approximately 80 to 100 samples. A total of approximately 300 samples will be prepared and tested in this plan by Auburn University, the University of Texas and the University of Nevada. The testing will be performed on aggregates from three sources. (Table 4)

Task 4. Reports and Information Exchange

A number of products will be produced from this project. These include the items listed below.

Subtask 4.1. Monthly Reports

Monthly reports will be prepared as required by NCHRP.

Subtask 4.2. Quarterly Reports

Quarterly reports will be prepared as required by NCHRP.

Subtask 4.3. Revise AASHTO T 283

Based on the results of this study a revised version of AASHTO T 283 will be prepared and submitted to the AASHTO Subcommittee on Materials.

Subtask 4.4. Draft Final Report and Executive Summary

A draft final report and Executive Summary will be prepared. The draft final report will contain a recommended acceptance criteria for AASHTO T 283 (tensile strength, tensile strength ratio) and a state-of-the practice for field QC/QA with AASHTO T283. These recommendations will be based on the literature, NCHRP 9-7 study, WesTrack and other studies.

Subtask 4.5. NCHRP Review

The NCHRP panel and staff will review the draft final report, executive summary, users guide and revised test method.

Subtask 4.6. Final Report

A final report, executive summary, users guide and revised test method will be prepared based on the comments received from Subtask 4.5.

Table 1. Water Sensitivity Tests Comparison

Test Parameter	ASTM D4867	AASHTO T283	Superpave
Specimen Size	62 mm x 100 mm	62 mm x 100 mm	95 mm x 150 mm
Mixing Temperature	Depends on Compaction Method (1)	Depends on Compaction Method	Equiviscous (0.170 Pa•s)
Loose Mix Curing	None	Cool at Room Temp. 2 hrs. Cure at 60°C - 16 hrs.	135 C - 4 hrs.
Compaction Temperature	Depends on Compaction Method (1) (1-2 hrs. in oven)	135 C (2 hrs. in oven)	Equiviscous (0.280 Pa•s)
Compacted Mixture Curing	0-24 hrs. @ Room Temp. Before Start of Testing	72 to 96 hrs. @ Room Temp. Before Start of Testing	Same as AASHTO T283
Air Void Content of Compacted Specimen, %	6-8	6-8	Same as AASHTO T283
Sample Grouping	Average Air Voids of Two sets of Samples About Same	Average Air voids of Two Sets of Samples About Same	Same as AASHTO T283
Saturation	•55 - 80% •About 20 in. Hg for 5 min. •Calculations Different than AASHTO T283	•55-80% •10-26 in. Hg for 5-10 min. •Calculation Different than ASTM D4867	Same as AASHTO T283
Swell Determination	yes	no	Same as AASHTO T283
Freeze	-18 $\pm$ 2 C for min. 15 hrs. (Optional by Note)	-18 $\pm$ 3 C for min. 16 hrs. Remove by Note	Same As AASHTO T283
Water Soak	60 $\pm$ 1.0 C for 24 hrs.	60 $\pm$ 0.1 C for 24 $\pm$ 1 hr.	Same As AASHTO T283
Strength Property	Indirect Tensile at 25 $\pm$ 1 C with Loading Rate of 51 mm per min.	Indirect Tensile at 25 $\pm$ 1 C	Same As AASHTO T283
Precision and Bias	yes	no	no

(1) - Use mixing temperature as specified by:
Marshall Compaction (ASTM D1559, AASHTO T245)
Kneading Compaction (ASTM D1561, AASHTO T247)
Corps of Engineers Gyratory (ASTM D3387)
Compression (ASTM D1074)

Table 2: Statistical and Engineering Based Experimental Plan - Task 2

Compaction		Gyratory (150 x 95 mm)*												Marshall (100 x 62 mm)**											
% Saturation		55				75				90				55				75				90			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																								
Source 1 Nevada (N)	None	E	X	X	E	X	X	X	X	X	E	E	X	E	E	E	E	E	E	E	E	E	E	E	X
	16 h/60° C	E	X	X	E	X	X	E	X	X	E	X	X	E	E	E	E	E	X	E	E	E	E	E	E
	2 h/135° C	X	X	X	X	X	E	E	X	E	X	X	E	E	E	X	E	X	E	E	E	E	E	E	E
	4 h/135° C	X	E	E	X	E	X	X	E	X	X	X	X	E	E	X	E	E	E	E	E	E	X	E	E
Source 2 Alabama (A)	None	X	X		X	X		X	X		X	X		X							X				
	16 h/60° C	X		X	X		X	X		X	X		X				X								
	2 h/135° C		X	X		X	X	X	X	X			X								X				
	4 h/135° C		X	X		X			X	X	X	X	X									X			
Source 3 Colorado (C)	None	X			X		X	X		X	X	X	X							X					
	16 h/60° C	X	X		X	X		X	X		X	X		X											
	2 h/135° C	X		X	X	X	X		X		X	X											X		
	4 h/135° C		X	X		X	X	X	X	X			X				X								

Table 2: Statistical and Engineering Based Experimental Plan - Continued

Compaction		Gyratory (150 x 95 mm)*												Marshall (100 x 62 mm)**											
% Saturation		55				75				90				55				75				90			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																								
Source 4 Maryland (M)	None	X	X	X		X			X		X	X			X										
	16 h/60° C		X	X	X	X	X	X		X		X												X	
	2 h/135° C	X			X		X	X		X	X	X	X		X									X	
	4 h/135° C	X	X		X	X		X	X		X	X						X			X				
Source 5 Texas (T)	None	X			X	X	X		X	X		X						X							
	16 h/60° C	X	X	X		X		X		X	X	X	X			X						X			
	2 h/135° C		X	X	X	X	X	X		X	X		X	X						X					
	4 h/135° C	X		X	X		X		X		X	X													X

NOTES

X - Statistical Based Experiment

E - Additional Testing for Engineering Based Experimental

- Gyratory Samples

  58 sets x 9 samples = 522
  57 sets x 6 samples = 342
  Total 864

- Marshall Samples

  24 sets x 9 samples = 216
  21 sets x 6 samples = 126
  Total 342

Table 3: Engineering Based Special Studies - Task 2

Compaction		Gyratory (150 x 95 mm)				Gyratory (100 x 62 mm)				Marshall (100 x 62 mm)				Hveem (100 x 62 mm)			
% Saturation		75				75				75				75			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																
Source 1 Nevada (N)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	E,M		X,M		S		S		E,M		X,M		A		A	
Source 2 Alabama (A)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S,M		X,M		S		S		S,M		S,M		A		A	
Source 3 Colorado (C)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S,M		X,M		S		S		S,M		S,M		A		A	

Table 3: Engineering Based Special Studies - Continued

Compaction		Gyratory (150 x 95 mm)				Gyratory (100 x 62 mm)				Marshall (100 x 62 mm)				Hveem (100 x 62 mm)			
% Saturation		75				75				75				75			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																
Source 4 Maryland (M)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	X		S		S		S		X		S		A		A	
Source 5 Texas (T)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S		S		S		S		S		S		A		A	

Notes

X - Statistical Based Experiment (from Table 2)
E - Additional Testing for Engineering Based Experiment (from Table 2)
S - Speciality Study as part of NCHRP 9-13 (100 mm Gyratory sample)
M - Speciality Study as part of NCHRP 9-13 (influence of resilient modules on tensile strength)

- Samples for X and E Test Sequences shown on Table 2
- Samples for Test Sequence S
  9 sets x 9 samples = 81
  4 sets x 3 samples = 12
  Total 93
- Samples for Test Sequence M
  6 sets x 15 samples = 90
- Samples for Test Sequence A
  5 sets x 9 samples = 45

Table 4: Ruggedness Test Program*

Saturation, Percent	Low								High							
Freeze/Thaw	1 cycle				None				1 cycle				None			
Compacted Mix Aging	0-4**		88-96**		0-4		88-96		0-4		88-96		88-96		88-96	
Loose Mix Aging / Aggregate Source	*** Y	*** N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Source 1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Source 2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Source 3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

x - replicate samples for complete factorial incomplete, factorial (Latin Square or a Youden Square will be used to select final experiment. (approximately 80 to 100 samples per laboratory three laboratories Auburn University, University of Texas, and University of Nevada)

* To be conducted at University of Nevada, University of Texas an Auburn University Superpave Regional Centers
** Hours
*** Y - 4 hours @ 135 C
N - No Aging

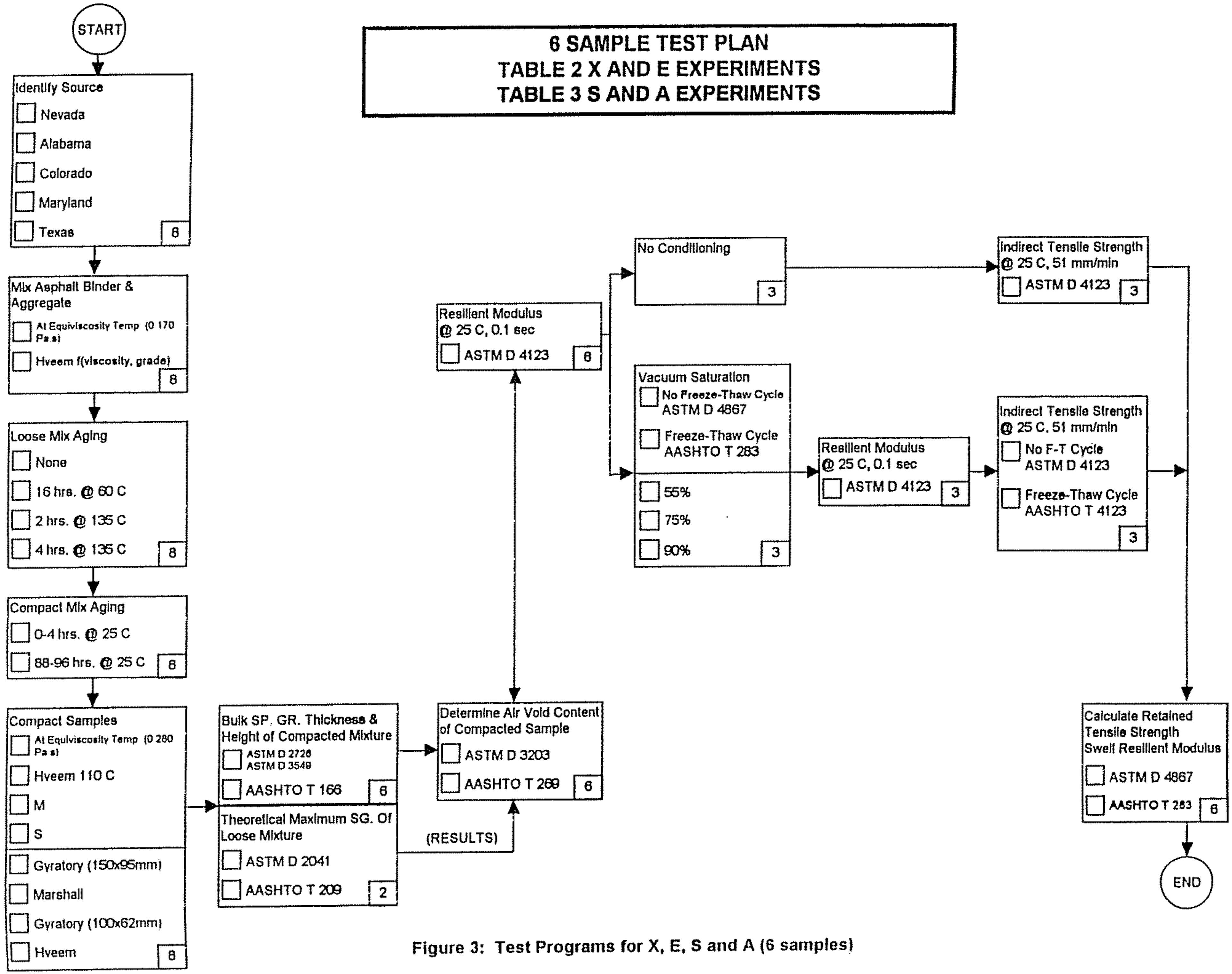


Figure 3: Test Programs for X, E, S and A (6 samples)

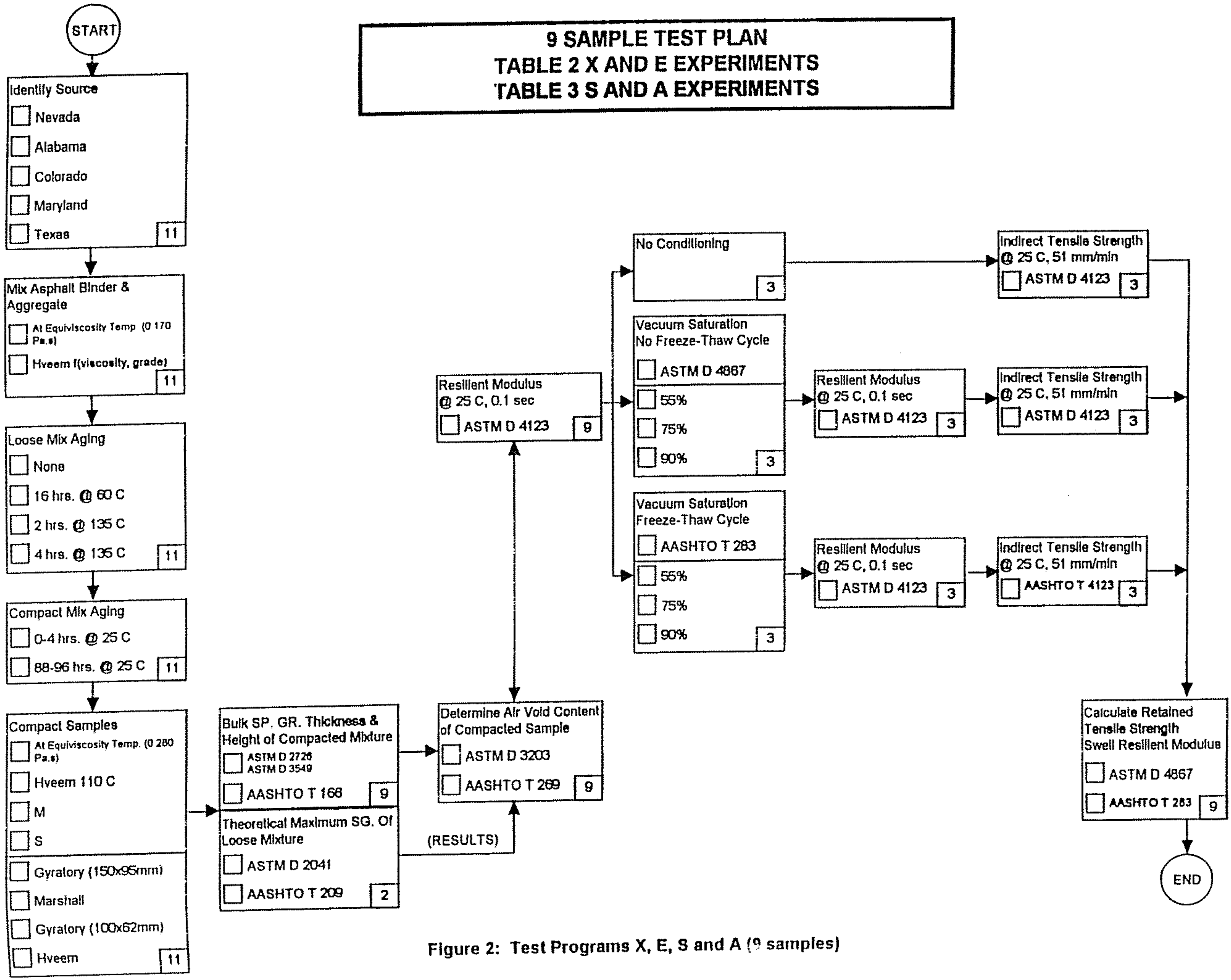


Figure 2: Test Programs X, E, S and A (9 samples)

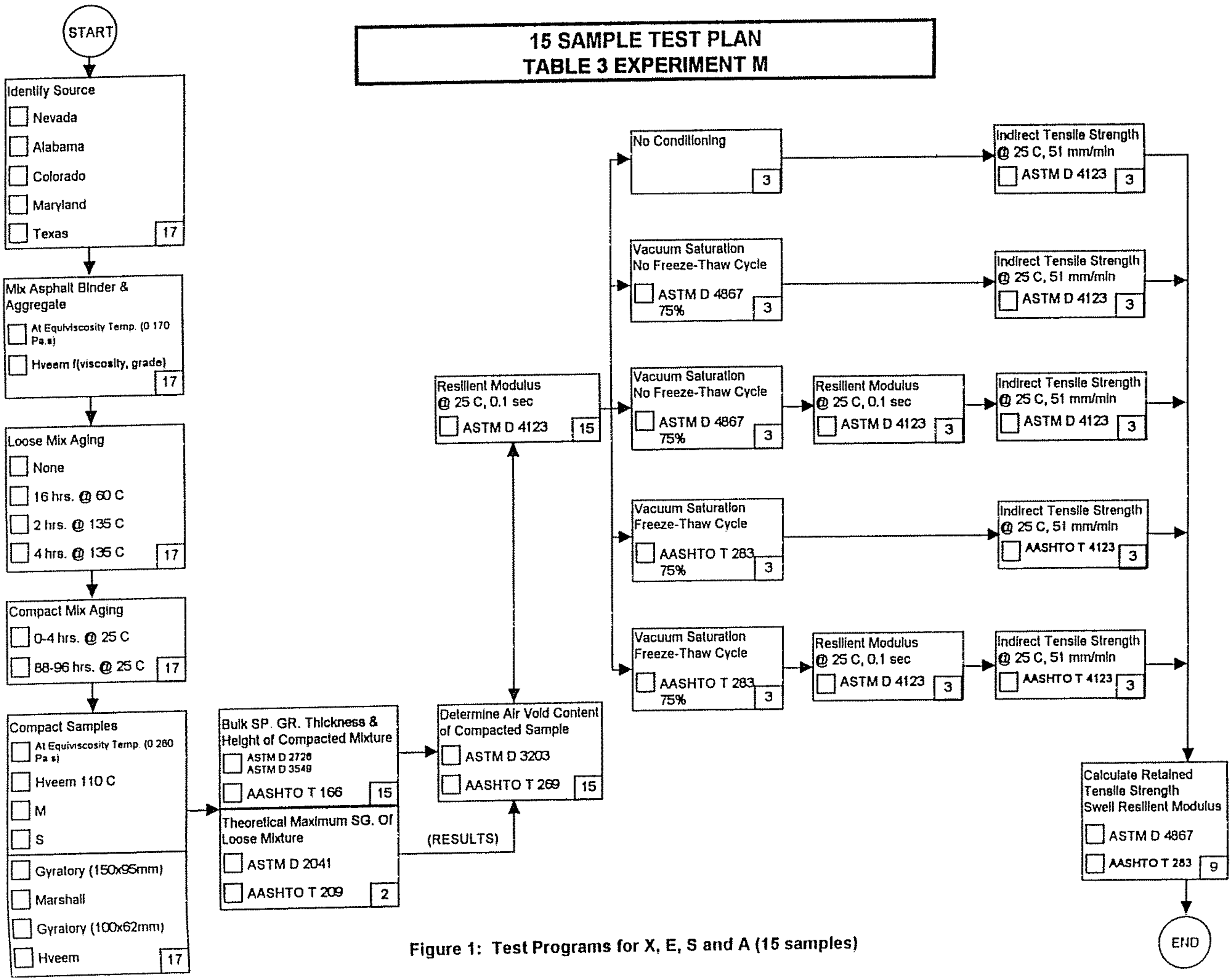


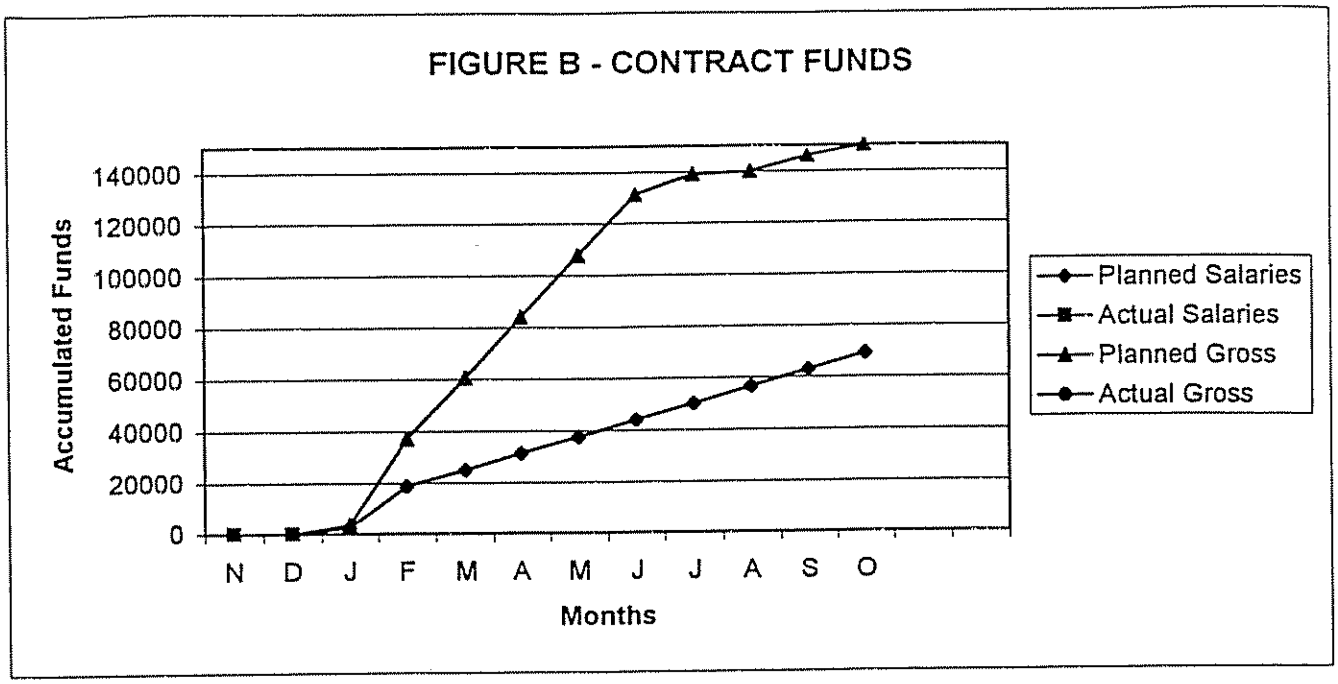
Figure 1: Test Programs for X, E, S and A (15 samples)

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NCHRP Project No. 9-13 Evaluation of Moisture Sensitivity Tests FY 98
Research Agency University of Nevada, Reno Month:

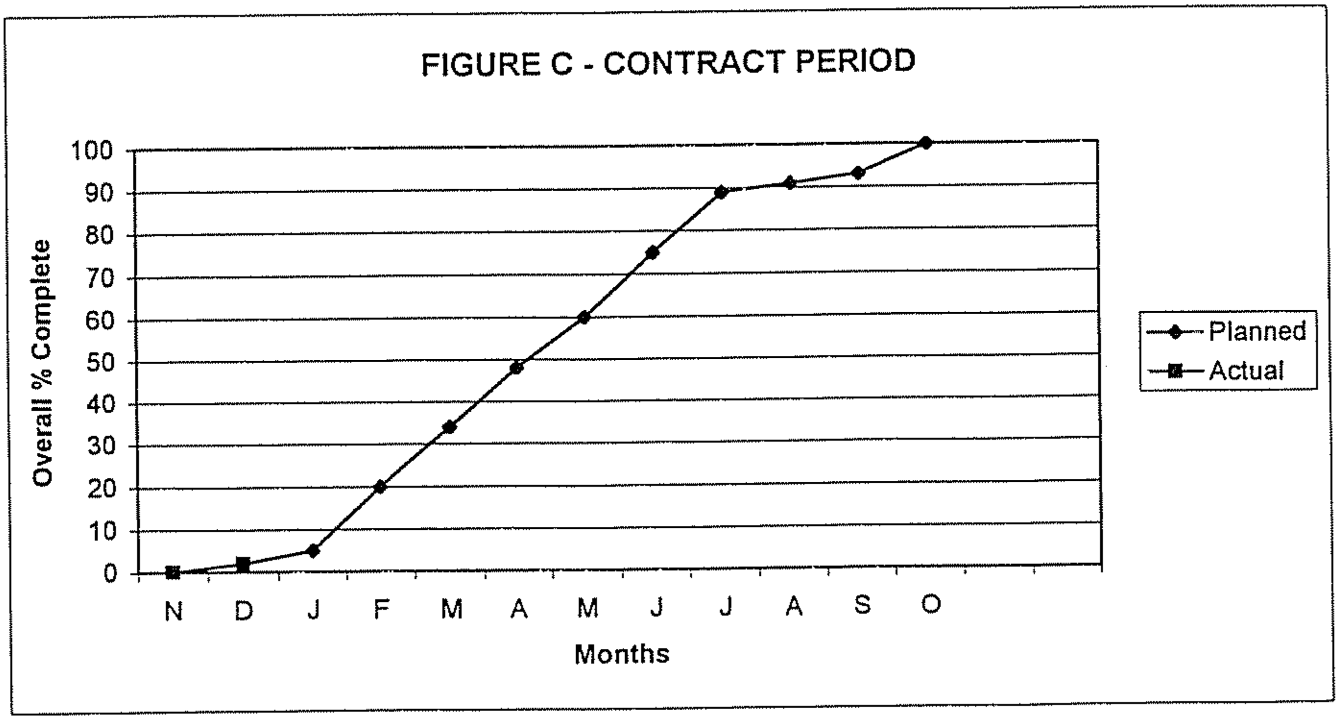
Research Phases	N	D	J	F	M	A	M	J	J	A	S	O	N	D	Est. % Compl.
1.0 Materials Sources	50	100													100
2.0 Correlations															
2.1 Test Program "M"			40	100											
2.2 Test Program "S"				40	100										
2.3 Test Program "A"				40	100										
2.4 Test Program "X" and "E"			15	30	45	60	75	90	100						
3.0 Ruggedness								40	100						
4.1 Monthly Reports	5		15	30		45	60		75	90		100			5
4.2 Quarterly Reports		20			40			70			100				20
4.3 Revise AASHTO Standards												100			
4.4 Draft Final Report								40	60						
4.5 NCHRP Review										100					
4.6 Final Report											40	60			
Overall % Completion	2	5	15	25	35	50	65	80	90	91	95	100			5

FIGURE A - OVERALL PROJECT SCHEDULE



Funds Expended %	0
Contract Amount	$150,000
Expended this Month	0
Total Exp. To Date	0
Balance	$150,000

Planned Salaries and Wages	$65,000
% Planned Salaries and Wages Expended	0
Salaries and Wages Estimated this Month	0
Salaries and Wages Spent this Month	0
Accumulated Salaries and Wages to Date	0
Balance	$65,000



Time Expended %	0.08
Starting Date	Nov.1, 97
Completion Date	Oct. 31, 98

QUARTERLY PROGRESS REPORT

to the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

on Project

9-13
Evaluation of Moisture Sensitivity Tests

for period

November 1, 1997 to December 31, 1997, 1997

from

University of Nevada, Reno

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NCHRP Project No. 9-13 Evaluation of Moisture Sensitivity Tests FY 98
Research Agency University of Nevada, Reno Month Dec. 1997

Research Phases	N	D	J	F	M	A	M	J	J	A	S	O	N	D	Est. % Compl.
1.0 Materials Sources															100
	50	100													
2.0 Correlations															
2.1 Test Program "M"															
			40	100											
2.2 Test Program "S"															
				40	100										
2.3 Test Program "A"															
				40	100										
2.4 Test Program "X" and "E"															
			15	30	45	60	75	90	100						
3.0 Ruggedness															
								40	100						
4.1 Monthly Reports															5
	5		15	30		45	60		75	90		100			
4.2 Quarterly Reports															20
		20			40			70			100				
4.3 Revise AASHTO Standards															
												100			
4.4 Draft Final Report															
								40	60						
4.5 NCHRP Review															
										100					
4.6 Final Report															
											40	60			
Overall % Completion	2	5	15	25	35	50	65	80	90	91	95	100			5

FIGURE A - OVERALL PROJECT SCHEDULE

NCHRP PROJECT 9-13

EVALUATION OF MOISTURE SENSITIVITY TEST

INTRODUCTION

General Observations

In the late 1970s and early 1980s a significant number of pavements in the United States began to experience distress associated with moisture sensitivity of hot mix asphalt materials. Premature rutting, raveling and wear of pavements were observed on many pavements. The causes of this sudden increase in pavement distress due to water sensitivity has not been conclusively identified. Practitioners and researchers suggest that changes in asphalt binders, decreases in asphalt binder content to satisfy rutting associated with increases in traffic (traffic volume, traffic weight and tire pressure), changes in aggregate quality, more widespread use of selected design features (open graded friction courses, chip seals and fabric interlayers) and poor quality control were primarily responsible for increased water sensitivity problems.

Regardless of the cause of this moisture related premature distress, methods are needed to identify hot mix asphalt behavior in the presence of moisture. Test methods and pavement performance prediction tools need to be developed that couple the effects of moisture on the properties of hot mix asphalt mixtures with performance prediction to estimate the behavior of the paving mixture to resist rutting, fatigue and thermal cracking when subjected to moisture under different traffic levels in various climates.

Current State of the Practice

Methods are presently not available to couple the effects of moisture on material properties with pavement performance prediction. Most public agencies use tests on loose or compacted hot mix asphalt to determine water sensitivity of the paving material. These tests results can not be used directly to rationally predict performance. Only limited correlations have been established between test results and observed performance of pavements which contain the tested hot mix asphalt.

The test methods listed below are national standard and are used by public agencies:

AASHTO T	283	"Resistance of Compacted Bituminous Mixture to Moisture Induced Damage"
ASTM	D 4867	"Effect of Moisture on Asphalt Concrete Paving Mixtures"

AASHTO T 165 "Effect of Water on Compressive Strength ASTM D 1075 of Compacted Bituminous Mixtures"

ASTM D 3625 "Effect of Water on Bituminous-Coated Aggregate Using Boiling Water

Other laboratory test methods are used by public agencies but are not national standards. These test methods include Marshall samples subjected to immersion, Hveem samples subjected to moisture vapor and a pedestal freeze-thaw test. The SHRP research program developed a test method that is presently as AASHTO Provision Standard (TP 34) "Moisture Sensitivity Characteristics of Compacted Bituminous Mixtures Subjected to Hot and Cold Climate Conditions."

The present Superpave methodology does not couple the water sensitivity of the hot mix asphalt paving mixture with climate and traffic to allow for pavement performance prediction for a particular paving project. The present Superpave methodology uses AASHTO T 283 to evaluate the susceptibility of hot mix asphalt to moisture. The moisture sensitivity test is performed on a laboratory mixed, gyratory compacted sample as part of the mixture design process. The sample is prepared at the design asphalt content and at the design gradation as defined by the job mix formula (JMF) for the project.

AASHTO T 283 and Superpave

AASHTO T 283 is based on research performed by Lottman and subsequent research performed by Root and Tunnicliff. The AASHTO method indicates that it is suitable for testing samples prepared as part of the mixture design process (laboratory mixed-laboratory compacted), as part of the plant control process (field mixed-laboratory compacted and cores taken from the roadway (field mixed-field compacted). Laboratory compacted samples can be prepared by the Marshall, Hveem or Corps of Engineers Gyratory method.

The AASHTO procedure ages the mixed and loose, hot mix asphalt for 16 hours at 60 C. After compaction to an air void content of 7 plus or minus 1 percent, the samples are extruded from the compaction mold and allowed to cure from 72 to 96 hours (3 to 4 days) at room temperature. The samples are then placed under water and a vacuum is used to saturate the samples to a level between 55 and 80 percent. A freeze cycle (16 hours at -18 C) and a thaw/soak cycle (24 hours at 60 C) are used to condition the sample prior to indirect tension testing.

The Superpave volumetric mixture design method uses the SHRP gyratory compactor to prepare 150 mm diameter by about 115 mm samples (according to the Superpave procedures samples are to be compacted to 95 mm in height at seven percent plus or minus one percent air voids for AASHTO T 283 testing). The Superpave sample preparation method conditions the mixed and loose, hot mix asphalt sample for 4 hour at 135 C (the 4 hour time may be reduced to 2 hours for testing volumetric, gyratory compaction properties only).

Thus, the differences between the AASHTO T 283 sample preparation method and the Superpave gyratory sample preparation method include the time and temperature of aging and the size of the sample (diameter and height).

SHRP recommended the use of AASHTO T 283 to evaluate the water sensitivity of hot mix asphalt within the Superpave volumetric mixture design system. This recommendation was made by the SHRP asphalt research team with little testing to establish retained tensile strength ratio correlations among sample preparation methods (sample conditioning, method of compaction and size of samples). This deficiency in the research was recognized by the SHRP asphalt research team, a NCHRP research project to define needed Superpave related research and the FHWA Asphalt Mixture Technical Working Group. Research project, NCHRP Project 9-13 " Evaluation of Moisture Sensitivity Tests" was developed to address some of the identified research needs relative to the use of AASHTO T 283 with the Superpave volumetric design method.

Project Objectives

The objective of this research project is to "evaluate AASHTO T 283 and to recommend changes to make it compatible with the Superpave system."

The NCHRP panel responsible for the development of this project recognized that research is also needed to determine correlations between moisture damage tests and field performance. This second objective will not be addressed in the research effort described below.

ACTIVITIES FOR REPORTING PERIOD

The detailed work plan for the project has been completed and submitted to NCHRP. Detailed laboratory testing programs have been established and the sequence of performing the six test programs has been establish.

The activities for the reporting period will be presented by Task and Sub-task as described in the detailed work plan and summarized below.

Task 1.0 - Material Sources

A meeting was held with the cooperating agencies for this project on September 22, 1997 in Colorado Springs as part of a FHWA Superpave Mixture Expert Task Group meeting. During the meeting the project proposal was briefly discussed and arrangements were made to sample and ship aggregates from Alabama, Colorado, Maryland, Nevada and Texas. These aggregates have been sampled, shipped and are in the University of Nevada laboratory. A listing of the aggregates nominal maximum size, type and relative water sensitivity is provided in Table 1.

The aggregates from Alabama, Colorado, Maryland and Texas were obtained from Superpave projects constructed in the summer of 1997. Mixture design information is available on this mixtures and will be used to establish the gradation and asphalt content of the samples to be tested in this project. The Nevada aggregate is from the same source as that used for the original construction of WesTrack. Since the aggregate from this source (Nevada-Dayton) was produced in 1997 rather than 1994 for WesTrack, a new Superpave volumetric design was performed to establish the design asphalt content for a gradation that matches the WesTrack test sections. The mixture design information for the Nevada-Dayton aggregate is attached as Appendix A.

Asphalt binders from each of the state projects were obtained and shipped by the cooperating agencies. These are the same binders that were used during construction and were obtained during construction except for the Colorado and Nevada aggregate sources. Asphalt binder was not available from the Colorado project at the time of construction. An asphalt binder was obtained from the same refinery source (same grade) as was used during construction. The WesTrack original construction asphalt binder will be used with the Nevada-Dayton aggregate source.

Table 1. Aggregates Selected for Study

State	Water Sensitivity	Nominal Max Size, mm	Gradation Type
Alabama	low	12.5 or 19	Coarse Limestone
Colorado	high	19	Fine Crushed Gr
Maryland	high	12.5	Coarse Limestone
Nevada	high	19	Fine Crushed Gr
Texas	low	19	Coarse Limestone

Task 2.0 - Correlationa Among Water Sensitivity Tests

This tasks has four subtasks associated with five test plans as describe in the detailed work plan. Processing of aggregates from Nevada-Dayton has been initiated. The initial phase of the processing is separation of the aggregate into individual size fraction. Size fraction separation of the Nevada-Dayton aggregate is nearly complete.

Subtask 2.1 - Test Program "M"-Influence of Resilient Modulus on Tensile Strength

No work was scheduled or performed on this subtask.

Subtask 2.2 - Test Program "S"-Comparison of 150 mm and 100 mm Gyratory Compacted Samples

No work was scheduled or performed on this subtask.

Subtask 2.3 - Test Program "A"-Kneading Compaction Comparison

No work was scheduled or performed on this subtask.

Subtask 2.4 - Test Program "X" and "E"-Main Test Program

No work was scheduled or performed on this subtask.

Task 3.0 - Ruggedness

Details of the ruggedness test program will be established after completion of Task 2.0. The Superpave Centers at Auburn University and the University of Texas will cooperate with the University of Nevada. No other work was scheduled or performed on this task.

Task 4.0 -Reports

Subtask 4.1-Monthly Reports

The monthly report for the month of November has been prepared.

Subtask 4.2-Quarterly Reports

The first quarterly report has been prepared (November-December 1997).

Subtask 4.3-Revise AASHTO Standards

No work was scheduled or performed on this subtask.

Subtask 4.4-Draft Final Report

No work was scheduled or performed on this subtask.

Subtask 4.5-NCHRP Review of Final Report

No work was scheduled or performed on this subtask.

Subtask 4.6-Final Report

No work was scheduled or performed on this subtask.

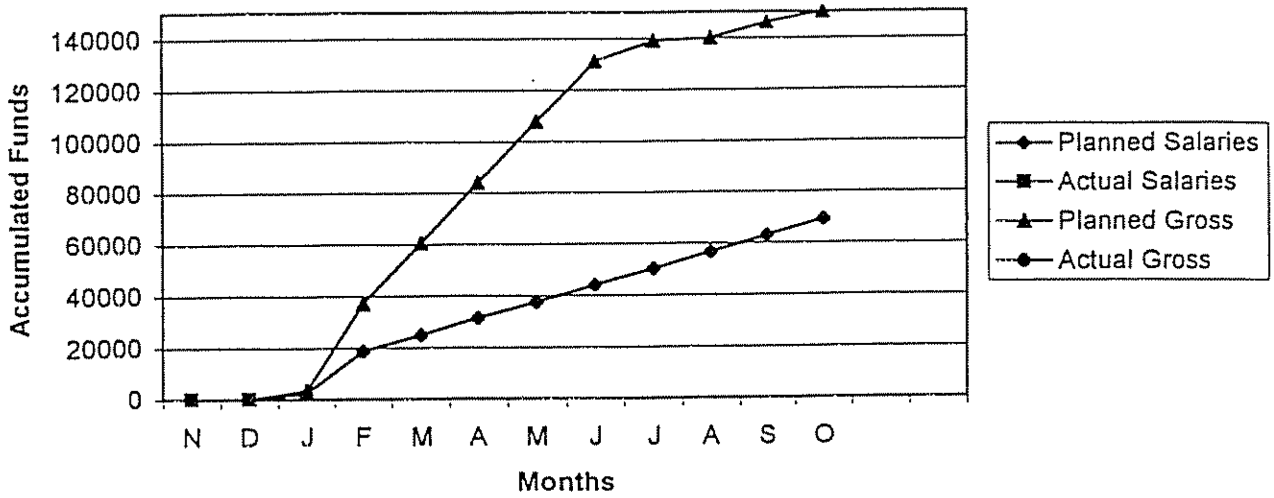
ACTIVITIES FOR NEXT QUARTER

1. Aggregates will be processed, samples will be prepared and testing will be completed on subtasks 2.1, 2,2 and 2.3.

2. Aggregate will be processed, samples will be prepared and some testing will be completed on subtask 2.4. That portion of subtask 2.4 which complements the testing of subtasks 2.1, 2.2 and 2.3 will be completed.

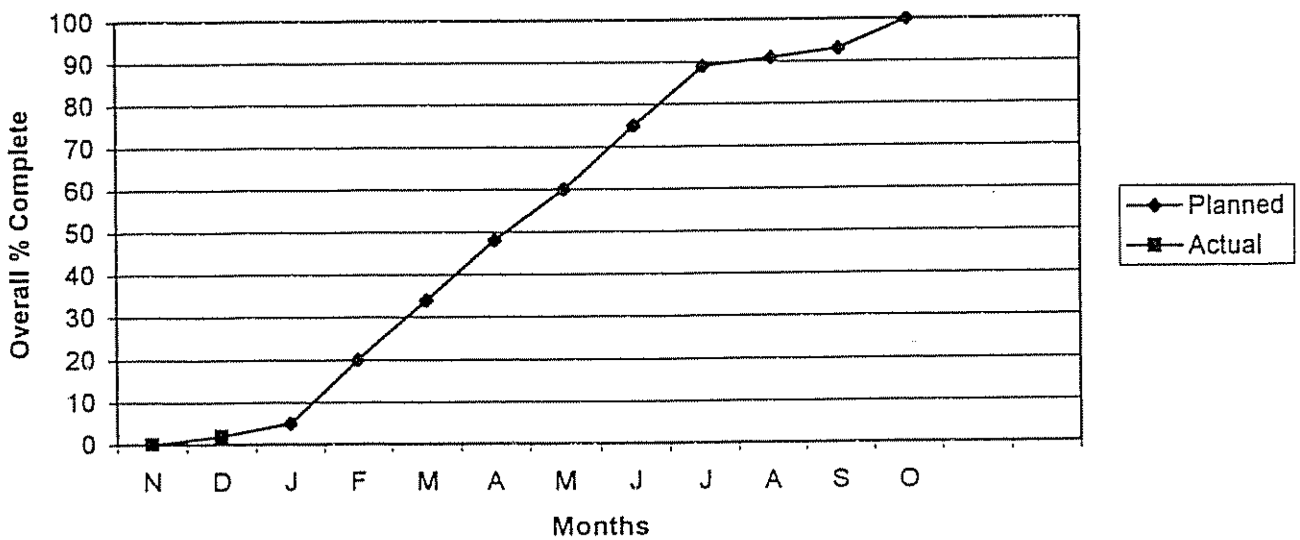
3. Two monthly and one quarterly report will be completed.

FIGURE B - CONTRACT FUNDS



Funds Expended %	0	Planned Salaries and Wages	$65,000
Contract Amount	$150,000	% Planned Salaries and Wages Expended	0
Expended this Month	0	Salaries and Wages Estimated this Month	0
Total Exp. To Date	0	Salaries and Wages Spent this Month	0
Balance	$150,000	Accumulated Salaries and Wages to Date	0
		Balance	$65,000

FIGURE C - CONTRACT PERIOD



Time Expended %	0 08
Starting Date	Nov.1, 97
Completion Date	Oct. 31, 98

QUARTERLY PROGRESS REPORT

to the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

on Project

9-13
Evaluation of Moisture Sensitivity Tests

for period

January 1, 1998 to March 31, 1998

from

University of Nevada, Reno

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NCHRP Project No. 9-13 Evaluation of Moisture Sensitivity Tests FY 98
Research Agency University of Nevada, Reno 2nd Quar. Report

Research Phases	N	D	J	F	M	A	M	J	J	A	S	O	N	D	Est. % Compl.
1.0 Materials Sources															100
	50	100													
2.0 Correlations															
2.1 Test Program "M"															
			40	100											70
2.2 Test Program "S"															
				40	100										15
2.3 Test Program "A"															
				40	100										10
2.4 Test Program "X" and "E"															
			15	30	45	60	75	90	100						20
3.0 Ruggedness															
								40	100						0
4.1 Monthly Reports															
	5		15	30		45	60		75	90		100			30
4.2 Quarterly Reports															
		20			40			70			100				40
4.3 Revise AASHTO Standards															
												100			0
4.4 Draft Final Report															
								40	60						0
4.5 NCHRP Review															
										100					0
4.6 Final Report															
											40	60			0
Overall % Completion	2	5	15	25	35	50	65	80	90	91	95	100			24

FIGURE A - OVERALL PROJECT SCHEDULE

NCHRP PROJECT 9-13

EVALUATION OF MOISTURE SENSITIVITY TEST

INTRODUCTION

General Observations

In the late 1970s and early 1980s a significant number of pavements in the United States began to experience distress associated with moisture sensitivity of hot mix asphalt materials. Premature rutting, raveling and wear of pavements were observed on many pavements. The causes of this sudden increase in pavement distress due to water sensitivity has not been conclusively identified. Practitioners and researchers suggest that changes in asphalt binders, decreases in asphalt binder content to satisfy rutting associated with increases in traffic (traffic volume, traffic weight and tire pressure), changes in aggregate quality, more widespread use of selected design features (open graded friction courses, chip seals and fabric interlayers) and poor quality control were primarily responsible for increased water sensitivity problems.

Regardless of the cause of this moisture related premature distress, methods are needed to identify hot mix asphalt behavior in the presence of moisture. Test methods and pavement performance prediction tools need to be developed that couple the effects of moisture on the properties of hot mix asphalt mixtures with performance prediction to estimate the behavior of the paving mixture to resist rutting, fatigue and thermal cracking when subjected to moisture under different traffic levels in various climates.

Current State of the Practice

Methods are presently not available to couple the effects of moisture on material properties with pavement performance prediction. Most public agencies use tests on loose or compacted hot mix asphalt to determine water sensitivity of the paving material. These tests results can not be used directly to rationally predict performance. Only limited correlations have been established between test results and observed performance of pavements which contain the tested hot mix asphalt.

The test methods listed below are national standard and are used by public agencies:

AASHTO T 283 "Resistance of Compacted Bituminous Mixture to Moisture Induced Damage"

The Superpave volumetric mixture design method uses the SHRP gyratory compactor to prepare 150 mm diameter by about 115 mm samples (according to the Superpave procedures samples are to be compacted to 95 mm in height at seven percent plus or minus one percent air voids for AASHTO T 283 testing). The Superpave sample preparation method conditions the mixed and loose, hot mix asphalt sample for 4 hour at 135 C (the 4 hour time may be reduced to 2 hours for testing volumetric, gyratory compaction properties only). Thus, the differences between the AASHTO T 283 sample preparation method and the Superpave gyratory sample preparation method include the time and temperature of aging and the size of the sample (diameter and height).

SHRP recommended the use of AASHTO T 283 to evaluate the water sensitivity of hot mix asphalt within the Superpave volumetric mixture design system. This recommendation was made by the SHRP asphalt research team with little testing to establish retained tensile strength ratio correlations among sample preparation methods (sample conditioning, method of compaction and size of samples). This deficiency in the research was recognized by the SHRP asphalt research team, a NCHRP research project to define needed Superpave related research and the FHWA Asphalt Mixture Technical Working Group. Research project, NCHRP Project 9-13 " Evaluation of Moisture Sensitivity Tests" was developed to address some of the identified research needs relative to the use of AASHTO T 283 with the Superpave volumetric design method.

Project Objectives

The objective of this research project is to "evaluate AASHTO T 283 and to recommend changes to make it compatible with the Superpave system."

The NCHRP panel responsible for the development of this project recognized that research is also needed to determine correlations between moisture damage tests and field performance. This second objective will not be addressed in the research effort described below.

ACTIVITIES FOR REPORTING PERIOD

The activities for the reporting period will be presented by Task and Sub-task as described in the detailed work plan and summarized below.

Task 1.0 - Material Sources

The binders from Alabama, Colorado, Maryland and Nevada were received at the University of Nevada laboratories. The binder from Texas was sampled and shipped but was not received.

Three of the binders that we received were heated and split from 5 gallon containers into quart containers for use in mixture preparation.

The binder from Texas was not sampled during construction of the Texas project. It was the asphalt supplied to the project and retained in the contractor's storage tank during the winter months. The Colorado asphalt is not the same as that used on the actual field project but was an asphalt of different grade obtained from the same refinery.

All aggregates were received at the University of Nevada laboratories. The Nevada-Dayton aggregate (used on WesTrack) was dried and about 90 percent of the aggregate required for the project was sieved on individual sieve sizes. About 85 percent of the Nevada aggregate was batched for mixture preparation. About 10 percent of the Alabama aggregate was dried. About 50 percent of the Colorado aggregate was dried and about 25 percent of the Texas aggregate was dried.

Processing of the Maryland aggregate has not been started. The aggregates from Alabama, Colorado, Maryland and Texas have not been sieved or batched.

Task 2.0 - Correlations Among Water Sensitivity Tests

This task has four subtasks associated with five test plans as described in the detailed work plan. Activities for the reporting period are summarized by subtask:

Subtask 2.1 - Test Program "M" - Influence of Resilient Modulus on Tensile Strength

Table 1 shows the test matrix for Test Programs "M", "S" and "A". The tests for the Nevada aggregate on Test Program "M" comparing the Gyrator 150 mm diameter samples with the Marshall 100 mm diameter samples were completed (see shaded portion of Table 1).

Conversations with two states that have performed a limited number of tests on 150 mm and 100 mm diameter samples suggest that substantial differences exist as a result of sample size and/or compaction method. The interim report on subtasks 2.1, 2.2 and 2.3 in which 150 mm diameter Gyratory samples are compared with 100 mm diameter Marshall samples (subtask 2.1), 100 mm diameter Gyratory samples (subtask 2.2) and 100 mm diameter Hveem samples will be reviewed prior to initiating the majority of the testing on Subtask 2.4 (main experimental design).

Subtask 2.2 - Test Program "S" - Comparison of 150 mm and 100 mm Diameter Gyratory Compacted Samples

Compaction procedures were developed to prepared 150 mm and 100 mm Gyratory samples at the desired air void contents for the Nevada aggregate. Samples were prepared with the Nevada aggregate and testing was initiated. No other work was completed on this task as emphasis was placed on the Nevada aggregate tests early in the project and other aggregate sources were not processed to complete the task.

Subtask 2.3 - Test Program "A" - Kneading Compaction Comparison

No work was completed on this task. Aggregate preparation for aggregate sources other than the Nevada aggregate was not completed. This test program is being performed as part of a graduate student thesis and is not officially related to this project.

Subtask 2.4 - Test Program "X" and "E" - Main Test Program

Table 2 shows the test matrix for test programs "X" and "E". The shaded portion of the table indicates the testing that was completed. About 35 percent of the testing with the Nevada aggregate was completed. This represents about 15-20 percent of the total testing program for this task as most of the testing is scheduled with the Nevada aggregate.

As indicated previously, processing of aggregates and preparation of mixture from aggregates from other states has required considerable time due to the size of the aggregate requirements.

Task 3.0 - Ruggedness

Details of the ruggedness test program will be established after completion of Task 2.0. The Superpave Centers at Auburn University and the University of Texas will cooperate with the University of Nevada. No other work was scheduled or performed on this task.

Task 4.0 - Reports

Six subtask comprise this task. Progress relative to these subtasks are described below:

Subtask 4.1 - Monthly Reports

The monthly reports for January and February were prepared and mailed to NCHRP.

Subtask 4.2 - Quarterly Reports

This report constitutes the second quarterly report for the period January 1 to March 31, 1998. NCHRP Panel member comments on the first quarterly report (November 1 to December 31, 1997) were reviewed, and answers to their comments were mailed to the NCHRP Senior Program Officer.

Subtask 4.3 - Revise ASSHTO Standards

No work was scheduled or performed on this subtask.

Subtask 4.4-Draft Final Report

No work was scheduled or performed on this subtask.

Subtask 4.5-NCHRP Review of Final Report

No work was scheduled or performed on this subtask.

Subtask 4.6-Final Report

No work was scheduled or performed on this subtask.

Other Activities

The Initial NCHRP surveillance visit was conducted by Edward Harrigan on February 19, 1998. The laboratory testing facilities, test plan and management plans were reviewed and discussed.

The first stage data analysis on completed tests (see shaded areas on Tables 1 and 2) were completed. Retesting was completed on all test programs shown as completed. Retesting is based on a visual and statistical review of test results from replicate samples.

ACTIVITIES FOR NEXT QUARTER

An evaluation of study progress and work force requirements was completed. The full time technician hired for the initiation of the project will be retained until the end of the spring academic semester (as planned). During the summer months four full-time, trained graduate students will be available to complete the testing phase of the study.

During the second quarter of 1998 emphasis will be placed on processing materials and early completion of Subtasks 2.1, 2.2 and 2.3 which allows for comparison of sample size (150 mm versus 100 mm diameter samples prepared by Gyratory, Marshall and Hveem compaction). An interim report will be prepared and reviewed by the project panel. A review of the test plan for subtask 2.4 will be made during this process.

Work will continue on Subtask 2.4 (main test program) during the next quarter. The amount of work will depend upon completion and review of the test results from subtasks 2.1, 2.2 and 2.3 as well as a review of findings from limited state studies comparing 150 mm and 100 mm samples.

Several states will be contacted to obtain information relative to test results on 150 mm versus 100 mm sample testing programs. A telephone contact or a questionnaire will be performed after consultation with NCHRP.

Two monthly and one quarterly report will be completed.

CONCERNS/PROBLEMS

Due to contract signing delays at the University contract office, the large amount of aggregate material required for processing and the academic calendar, we will formally request a two month extension (at no cost increase). We will request that the ending date be moved from October 31 to December 31, 1998. The laboratory work will be completed by the end of August 1998 and the draft final report will be completed by September 30, 1998.

Table 1 : Engineering Based Special Studies - Task 2

Compaction		Gyratory (150 x 95 mm)				Gyratory (100 x 62 mm)				Marshall (100 x 62 mm)				Hveem (100 x 62 mm)			
% Saturation		75				75				75				75			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregat e	Loose Mix Aging																
Source 1 Nevada (N)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	E,M		X,M		S		S		E,M		X,M		A		A	
Source 2 Alabama (A)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S,M		X,M		S		S		S,M		S,M		A		A	
Source 3 Colorado ©	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S,M		X,M		S		S		S,M		S,M		A		A	

TASK 2

Table ~~7~~ 1: Engineering Based Special Studies - Continued

Compaction		Gyratory (150 x 95 mm)				Gyratory (100 x 62 mm)				Marshall (100 x 62 mm)				Hveem (100 x 62 mm)			
% Saturation		75				75				75				75			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																
Source 4 Maryland (M)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	X		S		S		S		X		S		A		A	
Source 5 Texas (T)	None																
	16 h/60° C																
	2 h/135° C																
	4 h/135° C	S		S		S		S		S		S		A		A	

Notes

X - Statistical Based Experiment (from Table 2)
E - Additional Testing for Engineering Based Experiment (from Table 2)
S - Speciality Study as part of NCHRP 9-13 (100 mm Gyratory sample)
M - Speciality Study as part of NCHRP 9-13 (influence of resilient modules on tensile strength)

- Samples for X and E Test Sequences shown on Table 2
- Samples for Test Sequence S
  9 sets x 9 samples = 81
  4 sets x 3 samples = 12
  Total 93
- Samples for Test Sequence M
  6 sets x 15 samples = 90
- Samples for Test Sequence A
  5 sets x 9 samples = 45

Table 2: Statistical and Engineering Based Experimental Plan - Task 2

Compaction		Gyratory (150 x 95 mm)*												Marshall (100 x 62 mm)**											
% Saturation		55				75				90				55				75				90			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																								
Source 1 Nevada (N)	None	E	X	X	E	X	X	X	X	X	E	E	X	E	E	E	E	E	E	E	E	E	E	E	X
	16 h/60° C	E	X	X	E	X	X	E	X	X	E	X	X	E	E	E	E	E	X	E	E	E	E	E	E
	2 h/135° C	X	X	X	X	X	E	E	X	E	X	X	E	E	E	X	E	X	E	E	E	E	E	E	E
	4 h/135° C	X	E	E	X	E	X	X	E	X	X	X	X	E	E	X	E	E	E	E	E	E	X	E	E
Source 2 Alabama (A)	None	X	X		X	X		X	X		X	X		X							X				
	16 h/60° C	X		X	X		X	X		X	X		X				X								
	2 h/135° C		X	X		X	X	X	X	X			X								X				
	4 h/135° C		X	X		X			X	X	X	X	X									X			
Source 3 Colorado (C)	None	X			X		X	X		X	X	X	X							X					
	16 h/60° C	X	X		X	X		X	X		X	X		X											
	2 h/135° C	X		X	X	X	X		X		X	X											X		
	4 h/135° C		X	X		X	X	X	X	X			X				X								

Table 2: Statistical and Engineering Based Experimental Plan - Continued

Compaction		Gyratory (150 x 95 mm)*												Marshall (100 x 62 mm)**											
% Saturation		55				75				90				55				75				90			
Freeze/Thaw		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
Compacted Mix Aging		Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
Aggregate	Loose Mix Aging																								
Source 4 Maryland (M)	None	X	X	X		X			X		X	X			X										
	16 h/60° C		X	X	X	X	X	X		X		X												X	
	2 h/135° C	X			X		X	X		X	X	X	X		X									X	
	4 h/135° C	X	X		X	X		X	X		X	X						X			X				
Source 5 Texas (T)	None	X			X	X	X		X	X		X						X							
	16 h/60° C	X	X	X		X		X		X	X	X	X			X						X			
	2 h/135° C		X	X	X	X	X	X		X	X		X	X						X					
	4 h/135° C	X		X	X		X		X		X	X													X

NOTES

X - Statistical Based Experiment

E - Additional Testing for Engineering Based Experimental

- Gyratory Samples

  58 sets x 9 samples = 522

  57 sets x 6 samples = 342

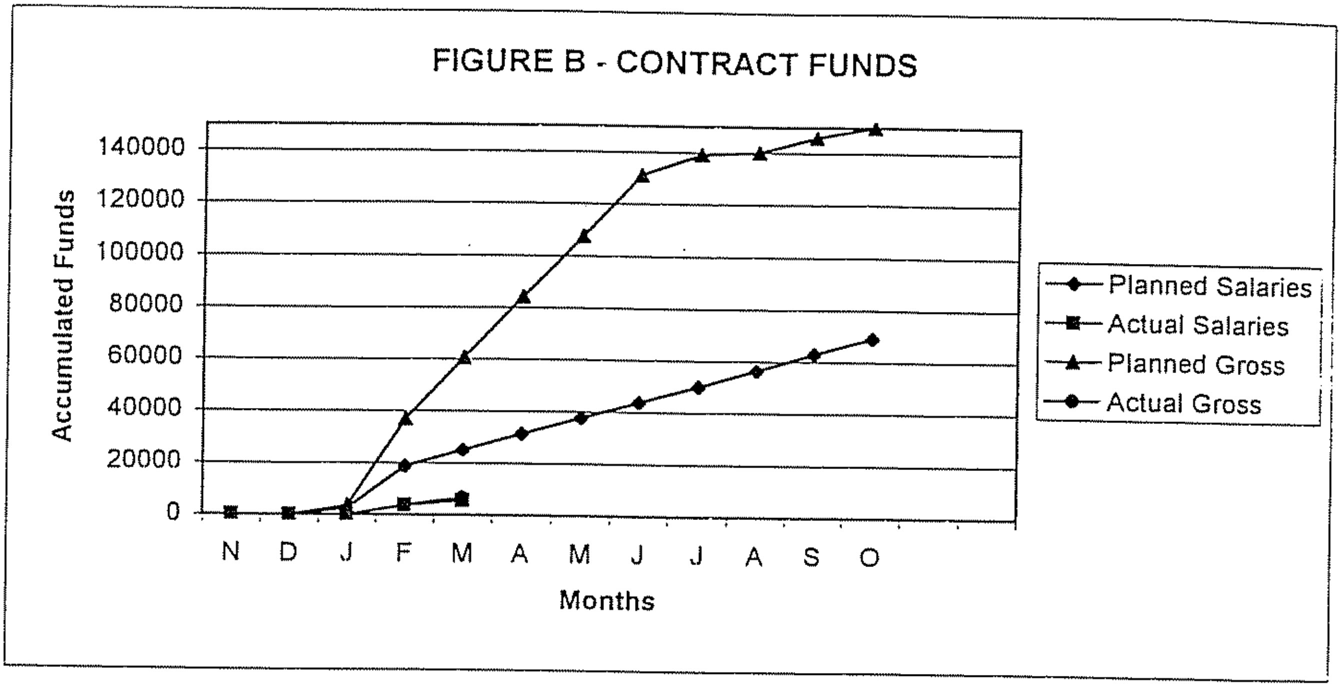
  Total 864

- Marshall Samples

  24 sets x 9 samples = 216

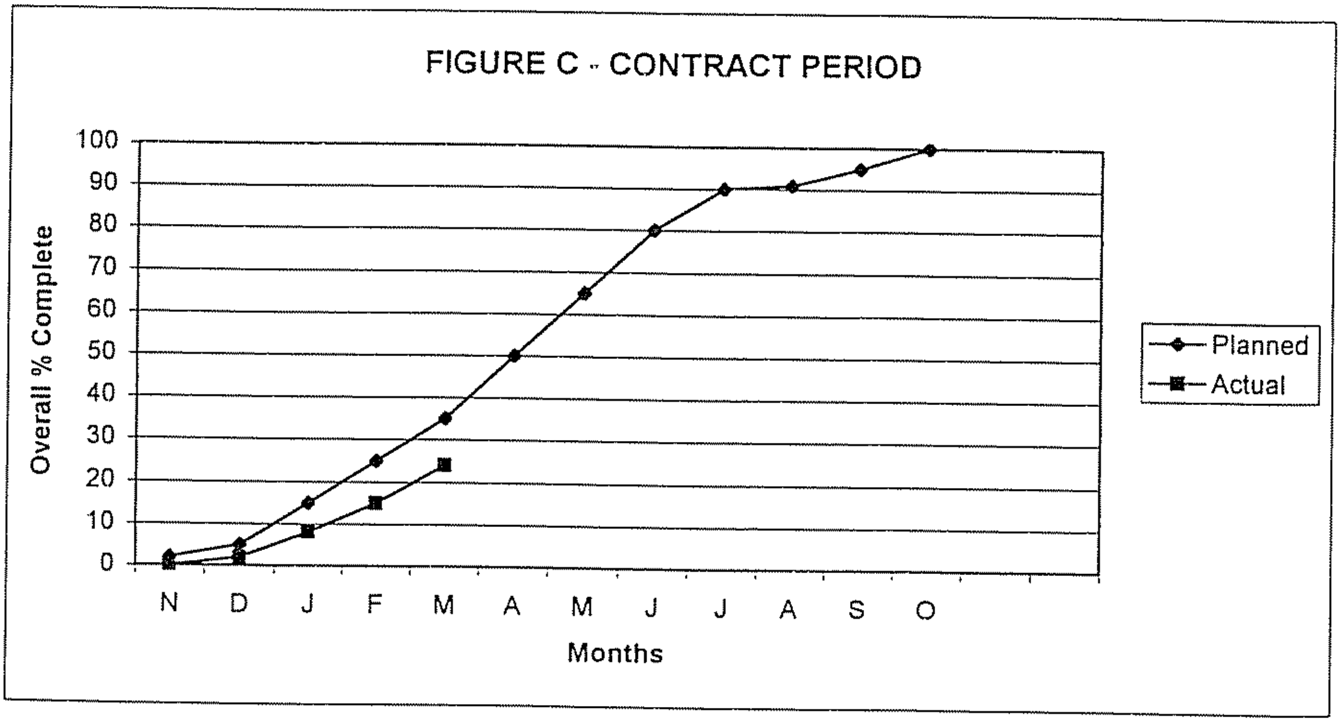
  21 sets x 6 samples = 126

  Total 342



Funds Expended %	6.83
Contract Amount	$150,000
Expended this Month	6,569
Total Exp. To Date	10,247
Balance	$139,753

Planned Salaries and Wages	$65,000
% Planned Salaries and Wages Expended	14%
Salaries and Wages Estimated this Month	2,500
Salaries and Wages Spent this Month	5,569
Accumulated Salaries and Wages to Date	9,247
Balance	$55,753



Time Expended %	41
Starting Date	Nov. 1, 97
Completion Date	Oct. 31, 98

MONTHLY PROGRESS REPORT

to the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

on Project

9-13
Evaluation of Moisture Sensitivity Tests

for period

April 1, 1998 to April 30, 1998

from

University of Nevada, Reno

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NCHRP Project No. 9-13 Evaluation of Moisture Sensitivity Tests FY 98
Research Agency University of Nevada, Reno Month: April

Research Phases	N	D	J	F	M	A	M	J	J	A	S	O	N	D	Est. % Compl.
1.0 Materials Sources	50	100													100
2.0 Correlations															
2.1 Test Program "M"			40	100											70
2.2 Test Program "S"				40	100										15
2.3 Test Program "A"				40	100										10
2.4 Test Program "X" and "E"			15	30	45	60	75	90	100						45
3.0 Ruggedness								40	100						0
4.1 Monthly Reports	5		15	30		45	60		75	90		100			45
4.2 Quarterly Reports		20			40			70			100				40
4.3 Revise AASHTO Standards												100			0
4.4 Draft Final Report								40	60						0
4.5 NCHRP Review										100					0
4.6 Final Report											40	60			0
Overall % Completion	2	5	15	25	35	50	65	80	90	91	95	100			27

FIGURE A - OVERALL PROJECT SCHEDULE

MEMORANDUM

To: Edward T. Harrigan, Senior Program Officer

From: Jon A. Epps and Peter Sebaaly
Co-Principal Investigators

Subject: April 1998 Progress Report

PROJECT OBJECTIVE

The objective of this project is to evaluate AASHTO T 283 test method and to recommend changes to make it compatible with the Superpave system.

ACTIVITIES FOR REPORTING PERIOD

Task 1.0 - Material Sources

1. A shipment of asphalt binder from the Texas project was received but the quantity was too small to complete all testing. A request for more asphalt binder was made to TxDOT. The University of Nevada received sufficient quantity of the Texas project asphalt binder.

   The receipt of the Texas asphalt binder completes the subtask associated with obtaining the asphalt binders from the five projects (Alabama, Colorado, Maryland, Nevada and Texas).

2. Major emphasis was placed on aggregate processing during the month of April. The first experimental test programs that will be completed are:

   "M" Influence of Resilient Modulus on Tensile Strength,

   "S" Comparison of 150 mm and 100 mm Diameter Gyratory Compacted Samples,

   "A" Comparison of 150 mm gyratory and 100 mm Diameter Hveem Compacted Samples, and

   Comparisons of 150 mm Gyratory and 100 mm Diameter Marshall Compacted Samples (parts of test programs "E," "X" and M).

These test programs require the use of aggregates from all five projects and hence the emphasis on processing aggregates during this portion of the project. The large amount of aggregate that must be removed from shipping containers, dried, sized and batched required the majority of the effort during this month.

3. Ninety percent of the Dayton, Nevada aggregate was dried, sized and batched for testing. About ninety percent of the Colorado aggregate was dried and sized. The Alabama and Texas aggregates were dried but not sized. Work has not been initiated on the Maryland aggregate.

Task 2.0 - Correlations Among Water Sensitivity Tests

1. A decision was made at the end of March that additional testing on this task should be stopped until the aggregates are processed. Samples that were in the test sequence at the end of March were completed. No new tests plans were started during the month of April. The quarterly report for January-March 1998 showed the progress on this task.

2. Data sheets and calculation spread sheets were developed for the test programs. Filing systems for "raw laboratory data" were established.

Task 3.0-Ruggedness

1. No activity for the reporting period.

Task 4.0-Reports

1. The monthly report was completed during the reporting period.

ACTIVITIES PLANNED FOR NEXT MONTH

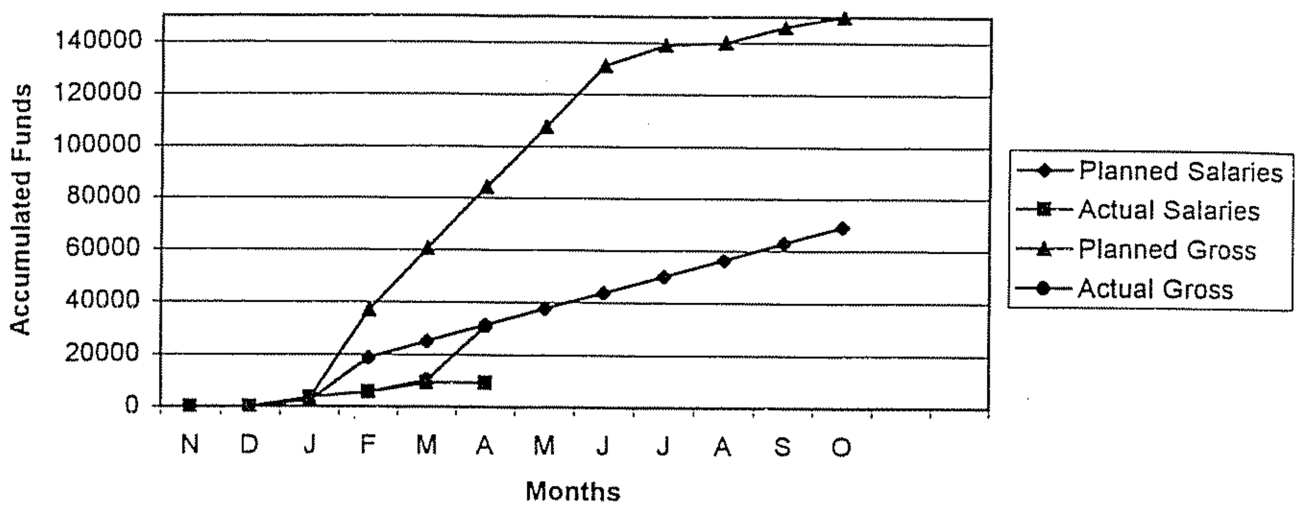
1. The majority of the work will be concentrated on processing aggregates for testing.

2. Water sensitivity testing in test programs "M," "S" and "A" will be initiated.

CONCERNS/PROBLEMS

1. The end of April and the beginning of May is a period in the academic calendar that requires that our students place more time on their academic programs. This is the slow period in terms of numbers of students' hours available to work on our research program. During the summer months, most students work full-time. Productivity will increase dramatically.

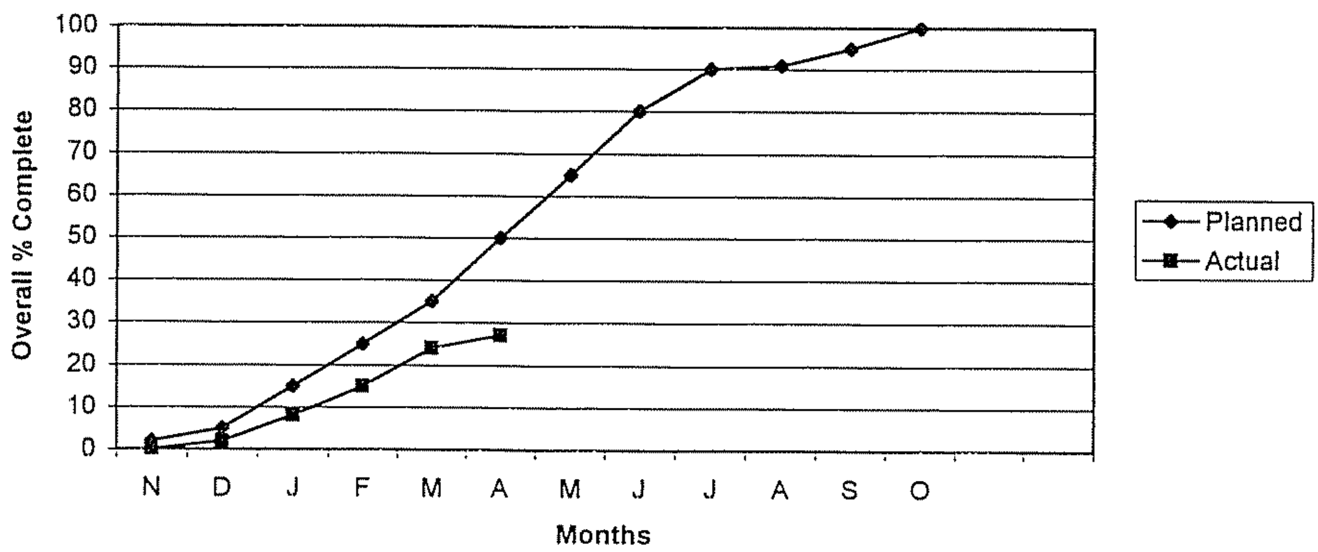
FIGURE B - CONTRACT FUNDS



Funds Expended %	21%
Contract Amount	$150,000
Expended this Month	20,609
Total Exp. To Date	30,856
Balance	$119,144

Planned Salaries and Wages	$65,000
% Planned Salaries and Wages Expended	14%
Salaries and Wages Estimated this Month	6,280
Salaries and Wages Spent this Month	0
Accumulated Salaries and Wages to Date	9,247
Balance	$55,753

FIGURE C - CONTRACT PERIOD



Time Expended %	50
Starting Date	Nov. 1, 97
Completion Date	Oct. 31, 98